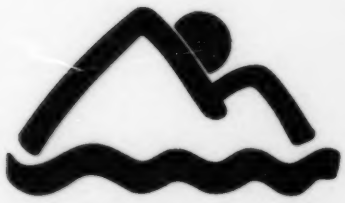
BC Environment

British Columbia Municipal Composting Resource Guide

Ministry of Environment, Lands and Parks

February 1992



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EXECUTIVE SUMMARY

This report was prepared by Co-op student Michelle Popadynec for the B.C. Ministry of Environment's (MOE) Municipal Waste Branch as part of the Ministry's mandate to promote composting as a waste reduction/recycling strategy within the Province. The B.C. Composting Resource Guide is a summary of composting options and technology available at the different scales of backyard, neighbourhood, and central composting. The major intent of the Resource Guide is provide information to local governments preparing organic waste recycling programs that will significantly reduce the amount of Municipal Solid Waste (MSW) going to B.C. landfills and create a useful resource in the form of compost. Mention of a specific vendor within this report does not mean that competitors should be overlooked. Other MOE initiatives intended to influence composting technology include: (1) the Regulation for the Production and Use of Compost from Municipal Solid Waste for British Columbia, which includes appropriate criteria for pathogen kill and compost quality for end-use; (2) financial assistance to municipal governments and other organizations for implementing programs that provide valuable information and infrastructure pertaining to composting; and (3) partial funding for a "how to" booklet on urban composting, being put together by Michael Levenston, Executive Director of City Farmer - Canada's Office of Urban Agriculture. The research for the Resource Guide involved a review of available journals (Biocycle, Waste Age, Resource Recycling), vendor proposals, and contact with industry representatives, waste consultants, municipalities and regional districts. The editors of Biocycle should be thanked for the list of equipment provided in Appendix B.

It was found that the European/Canadian trend towards source-separated composting of organics at all scales is thought to be more beneficial in terms of minimum contamination of the product, environmental quality and individual participation rates in waste management programs than the composting of mixed MSW. In a review of the available literature on mixed MSW composting, it was generally concluded that compost produced by "Resource Recovery Facilities" (RRFs) or "Recycling Plants" would not be classified as a high quality compost by the B.C. Regulations. Municipalities choosing the option of RRFs to separate recyclables and produce compost should, therefore, demand a system that has efficient sorting and removal of glass, metal, plastics, etc. prior to composting. Ideally, the sorting of organics from recyclables should be done prior to collection to avoid the leaching of metals and other contaminants into the organic fraction once they are introduced into a common container.

The B.C. Regulations require a high quality compost product, particularly with respect to metal concentrations and percent of allowable foreign matter, in order to qualify for widespread use. Thus, the focus of the report is on the composting of source-separated organics, and associated collection/ storage systems, methods, and equipment.

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1.0 INTRODUCTION

A potentially significant way to reduce the volume of solid waste entering landfills in B.C. is through composting initiatives. Composting is the biological decomposition of the organic constituents of waste under controlled conditions. Organics such as food and yard waste, which constitute from 30-40% of the waste stream in B.C., can be diverted from the landfill and recycled into a useful product called humus by composting. Other benefits of composting include waste stabilization, pathogen inactivation, nutrient and land reclamation, and sludge drying (Polprasert, 1989). The addition of sewage sludge or animal wastes to Municipal Solid Waste (MSW) may provide compost that is acceptable in many places as a growing medium, thus replacing peat harvested from wetland or other soil amendments made from finite resources (Warmer Fact sheet, 1991). Another major advantage of composting, often overlooked, is its effect on waste generator attitudes and behaviour. The separation of organics by individuals for composting at home or at a central facility adds value to something that was once regarded as useless.

Disadvantages of composting may include the high capital costs required for central facilities (equipment, labour, infrastructure), nuisance concerns when the operation is not well managed (odour, pests), and waste generator inconvenience in having to sort out organics. However, implementation of a well-designed system will prove beneficial, both environmentally and socio-economically.

There are a number of strategies that can be followed by municipalities to reduce the organic fraction of waste entering B.C.'s landfills. These include encouraging backyard and neighbourhood composting or investing in central MSW composting plants. The strategy devised by a municipality for composting will depend on the volume of waste, funds available for the purchase of equipment/education, land available and, among others, markets for the finished product. This report is an overview of the major composting options in B.C., including the technology available, advantages and limitations, collection and storage systems, markets, and reference to regulations where applicable. As well, proposed and exiting composting initiatives in B.C. and other jurisdictions are included with a discussion of some of the factors which contributed to the selection of a certain program. It is intended that this "Resource Guide" will assist local governments in choosing the most appropriate composting strategy for reducing the organic fraction of MSW.

2.0 PRINCIPLES OF COMPOSTING

Regardless of the scale or type of composting operation, producing an odourless, nutritious humus requires certain physical and chemical conditions that will best facilitate the decomposition of organic material. Time, temperature, nutrient ratios, aeration, particle size and moisture are all important factors in composting. It is important to note that biological decomposition can take place either aerobically -with the presence of oxygen or anaerobically -in absence of oxygen. Modern composting is usually aerobic, and thus requires aeration of the material through periodic turning or else forced aeration for the survival of aerobic microbes. However, any aerobic composting operation can become anaerobic in full or in part if it is not managed properly. Anaerobic composting is generally characterized by a slower rate of decomposition, low temperatures and foul odours, although with high tech operations such as those employed to produce biogas in a fabricated digester this is not always so.

Aerobic composting and its associated infrastructure is the focal point of this paper. There are generally two biological stages associated with aerobic decomposition which are important, not only in the breakdown of material by microorganisms, but also the destruction of disease-causing bacteria, pathogens, viruses and also weed seeds in the organic pile. The mesophyllic stage in the composting process is characterized by active bacteria which favour a moderate temperature range of 20^0 C to 45^0 C. The thermophilic stage is characterized by active bacteria which favour a high temperature range of 45^0 C to 75^0 C. It occurs early in a composting process before the mesophyllic stage and is associated with a high rate of decomposition. If high temperatures are not being achieved in the compost pile, there are a number of limiting biological factors that could be contributing to the problem (see Table 1).

Table 1
Compost Problem Chart

Symptom	Problem	Solution
1) Odours (a) hot compost	Too much nitrogen	Will not impede decomposition. Add carbon- rich wastes.
(b) compost not	Too much water	Mix in drier materials and rebuild compost. Protect from rain. Provide drainage.
2) Compost does not attain temp.	Not enough nitrogen	Add nitrogen-rich wastes or fertilizer kelp meal, etc.
	Not enough water	Add water until wastes are moist, not wet or soggy.
	Too much water	same as 1 (b)
	Not enough oxygen	Shred and turn compost from every 3-4 days to once a month.
3)Pest infestation: dogs,	Poor location	Build compost at least 2' away from fences.
	Improper food scraps	Don't add meats, fats, bones, other animal wastes.
	Food scraps not covered	Place veg. and fruit wastes in the centre of the compost and cover with a layer of soil.
4) Decomposition occurs but very slowly	Wastes not finely	Turn or rebuild compost with shredded waste. Run mower over leaves, etc., chop stems etc.
	Anaerobic conditions	Turn compost pile at least once a month to provide oxygen. Maintain proper moisture balance and C/N ratio.

source: B.C. Environment, 1983 . Garbage is Resource Full.

Moisture is an important limiting factor in composting operations. Organic material should be kept moist but not wet or soggy. If the organics contain too much water, the oxygen will be displaced, leading to anaerobic conditions and odours. As well, excess water will cause nutrients to be leached away from the compost. Sawdust and other dry compostables are often added to "wet" materials in central composting facilities and backyard composters alike to absorb excess water and achieve a moisture balance. If the material is too dry, decomposition will be inhibited. The minimum moisture content at which bacterial activity takes place is from 12 to 15%. As a rule-of-thumb, the moisture content becomes a limiting factor when it drops below 45 or 50% (Golueke, 1972). In practical terms, the material should have the consistency of a damp sponge (moist but not soaking wet).

Other important factors in the composting process are particle size, insulation capacity (ie. volume, shape of pile) and nutrient balance. These are discussed throughout the report to promote an understanding of the functions of the various technology and equipment associated with composting.

3.0 COMPOSTING ON-SITE

"On-site" composting systems, a more encompassing term for backyard composting (BYC), involves the composting of organic solid wastes at a residential dwelling site where the waste is generated by the residents of the dwelling and/or neighbouring units. Under the B.C. Regulation, the scale of a backyard operation is limited to a production not exceeding 60 cubic metres. This option is attractive to municipalities because it has no collection cost, and virtually no operating cost other than some capital costs if a municipality decides to subsidize the purchase of composters and/or initiate education programs. Through on-site composting initiatives, the awareness level surrounding solid waste will be elevated as individuals become involved in the actual maintenance of the compost pile and breakdown of organics. Hopefully, success in backyard composting will encourage waste generators to participate in other waste reduction techniques and programs:

"When one significant step is taken toward waste reduction or recycling in the household, as it is through backyard composting, subsequent steps begin to follow. Residents begin to change behaviours and attitudes. Backyard composting, presented in conjunction with information on solid waste volumes, begins to be viewed by participants in terms of the number of garbage cans filled or not filled each week" (Waters and Cox, 1990).

However, behaviour and attitude changes towards solid waste involve, not only an awareness of the problems, but education on how to compost on-site. Examples of educational tools for composting are demonstration compost facilities, information brochures, media articles, compost "hotlines" and personal instruction by trained volunteers. As well, many municipalities are choosing to provide composting containers to households, either free or at a reduced price, to ensure full participation in backyard composting. For example, the City of Vancouver has purchased 5,000 compost bins and is making them available to residents for $25 per unit, approximately half of the original purchase price. Residents who purchased compost bins from the City of Vancouver during an earlier pilot bin distribution program in August of 1990 were surveyed with regard to their participation and organic waste reduction. Preliminary data showed that "...over 95% of the bins are being used, and residents are reducing their household waste by approximately 200 to 300 kilograms per year or 20% to 30% (City of Vancouver, 1991).

3.1 Backyard composting:

Some municipalities such as metro Toronto have decided that the economies involved in providing composters to residents make it feasible to purchase a commercial unit in bulk and charge only a token fee, based on the theory that if residents had to pay something for these units they would be more inclined to value and use them (Taylor, 1990). A commitment to on-site composting, therefore, involves some cost to local and other governments but it is the least expensive and most "environmentally friendly" alternative for recycling organics from the residential sector. In an Ontario pilot project, it was found that approximately 32% of the waste generated by residents was intercepted by the composters, proving that backyard composting can be very effective as a municipal solid waste recycling strategy.

Equipment for home composting does not have to be elaborate. Yard waste as well as most food wastes can be piled in containers designed to facilitate breakdown of the organic material into humus. There are various commercial composters available as well as a number of bin designs for home construction.* Chippers for brush and a grinder for herbaceous debris can be used to reduce the particle size of yard waste for ease of handling and to allow for faster composting. This is important as large pieces of wood can take years to decompose. Chippers may be available for rent by the hour or by the day at local equipment rental shops, and if a few neighbours can be organized to process yard waste on the same day, the costs can be shared. As an option, community environmental organizations could purchase small chippers for local residents to borrow for backyard composting preparation. Alternatively, an axe or

clippers can be used to chop up large material, and leaves and small branches can be run over with the lawnmower to reduce the particle size of yard debris. Similarly, large pieces of food and garden waste such as corn cobs and plant stalks can be chopped up with a spade or shovel to increase the amount of surface area to be attacked by microorganisms.

3.2 Composting for apartment dwellers:

For apartment dwellers who do not have access to organic waste collection systems there are still options for food waste composting. The first option is through vermicomposting, which is a composting process utilizing red worms, *Eisenia foetida* and *Lumbricus rubellus*, in a container to break down organics. Vermicomposting can be carried out indoors or outdoors and can be done year-round with a minimum of effort by apartment dwellers or householders once the bin is set up. The containers can be made of wood or plastic and should provide one square foot of surface area for every pound of food waste per week. Two pounds of worms (approximately 2,000) are required to compost one pound of food waste. The worms require bedding material such as shredded newspaper or cardboard, shredded fall leaves, dried grass clippings etc. moistened to the level of a "wrung-out sponge", a small amount of sand or soil as grits, and food scraps. The Greater Vancouver Regional District (GVRD) and City Farmer do not recommend the inclusion of meats, dairy products, oily foods or grains in the worm bins because these items may lead to rodent problems.

A detailed book on how to carry out vermicomposting, including the building of the bin and compost harvesting is Worms Eat my Garbage by Mary Appelhof. This approach to composting may require some effort and education to overcome public resistance because worm composting is a new concept to most people. However, once people learn that worm composting is an excellent method to recycle household organic waste and provide educational opportunities to children, the concept may become accepted and spread to householders, apartment dwellers and schools.

The second on-site composting option for apartment dwellers is to set up a multifamily composting unit outside for food wastes. Finland has a pilot project for composting food wastes at this scale, utilizing 560-litre boxes called "Hot Compost Boxes" installed in high-rise apartment buildings to serve 15-30 families. Each of these boxes are managed in part by two families designated to monitor the temperature, and turn the compost for aeration and proper mixing of the organics. Bulking material such as chipped yard waste, leaves, finished compost and sawdust were added to the food wastes in order to provide porosity and structure, and absorb moisture from the wet food wastes. All of the compost was used for on-site landscaping but further investigation into this scale of on-site composting is needed to ensure the process occurs quickly and provides a high quality product (Scheinberg and Smoler, 1990).

As well, apartment dwellers in Vancouver have been recycling their food and yard wastes in a home-made composter located in the basement garage. The drum composter is made of heavy plywood approximately 6' high and 4' wide and is turned by a small motor. The drum is divided vertically into two separate compartments to allow composting to occur at different stages -fresh and semi-mature. The forty residents load approximately 100 pounds of food scraps into the composter, which is turned one or more times a week, in order to maintain proper operating conditions. All the compost is used in the gardens at the apartment building (Biocycle, 1991).

** City Farmer - Canada's Office of Urban Agriculture - is currently producing a "how to" book on urban home composting, with a focus on rodent-resistant bins. Some Health Departments stress that municipalities must promote the use of rodent-resistant bins as well as proper composting techniques in order to prevent pest problems.*

4.0 NEIGHBOURHOOD COMPOSTING (DEMONSTRATION GARDENS)

The development of a compost demonstration garden is one important way that municipalities and non-governmental organizations can educate residents about how to compost organics generated in the yard, garden and kitchen. Compost demonstration gardens are operating in Burnaby, Surrey, Vancouver, West Vancouver and Maple Ridge (see Table 2). At these sites, different types of compost bins are tested for their effectiveness judged by speed of composting, suitability for different types of organics etc., and this information is passed on to visitors. In addition to offering information on composting techniques, such sites work within a closed system by recycling the organics from the garden in various compost bins for use as a natural soil enhancer for growing food.

The demonstration food garden in the Vancouver neighbourhood of Kitsilano is planted with fruits, flowers and vegetables and generates local enthusiasm for urban gardening the natural way, without the use of commercial pesticides and fertilizers. "Non-gardeners" are often convinced that gardening is both possible and enjoyable - even in an urban setting, and residents who already grow a garden can learn about different designs such as raised beds and "environmentally friendly" methods of pest control. According to City Farmer there are many advantages associated with composting and gardening in an urban setting:

"City dwellers who produce food in backyard gardens, on rooftops or on apartment balconies are helping themselves with physical exercise and wholesome foods, while enjoying the therapy of relaxation. At the same time, they're saving energy by reducing demands on the petro-chemical hungry agribusiness and trucking industries, and avoiding dangerous pesticides" (City Farmer Info. Sheet, 1987).

Kelowna also has a demonstration composting site under construction, which will involve composting some material from off-site in the second stage. The first phase of the proposed project involves the building of a facility on a 446 square metre area at the present KEREDA recycling depot. It will be surrounded by a 2.4 metre wall, which will be decorated by murals painted by local artists to make it aesthetically pleasing. Inside, different types of home compost units will be displayed and available for demonstration. As well, four larger compost units will be in operation to process organics collected by the public. Demonstrations and workshops will be available for education about composting, both home and institutional. The intention is to start small and expand in phases into a larger and more comprehensive facility, the details of which have not yet been worked out. The City of Kelowna has commissioned a major study in order to evaluate all available options for composting the organic fraction of its waste.

King County, Washington has created two Recycling and Composting Demonstration Sites in suburban parks with the help of Master Recycler Compost volunteers (MRCs). The MRCs helped to build and develop the two permanent demonstration sites for about $10,000 U.S. with maintenance expected to be $3,000 per year and about $15,000 per year to train and equip MRCs with bins, books and tools. Although it is "difficult to measure the results of education programs in terms of tons of wastes diverted from the landfill or waste never generated at all..." (Putnam and Stenn, 1990), such programs are often important in changing peoples' attitudes regarding waste by encouraging changes in their daily shopping, consumption and disposal habits which is more important to solid waste reduction than to simply provide compost bins or collection services. Victoria, B.C. also has plans to develop a demonstration compost site and hire an educator to provide information about composting (see section 7.2).

Table 2

Compost Demonstration Gardens		
Burnaby 4856 Still Creek Ave North Burnaby, B.C. *Contact:* Bev Webber	**Maple Ridge** Community Organic Garden 12307 244th Street Maple Ridge, B.C. *Contact:* Joe O'Rourke (604) 467-0085 (rural garden)	**Maple Ridge** Seed Centre 11739 223rd Street Maple Ridge, B.C. (urban garden)
Surrey/Crescent Beach Compost Demo. Garden Camp Alexander 2916 McBride Ave. Surrey, B.C. V4A 3G2 *Contact:* Louise Robertson or Bill Mahoney (604) 535-0015 Ext. 16	**Vancouver (Kitsilano)** 2150 Maple Street Vancouver, B.C. V6J 3T3 *Contact:* Paul Henderson, City of Vancouver Engineering (604) 873-7190 or Michael Levenston of City Farmer (604) 685-5832	**West Vancouver** 15th & Argyle Vancouver, B.C. *Contact:* Kathleen Salbuvik 926-6486
Kelowna Kereda Recycling Depot *Contact:* Lloyd Manchester of Earthcare Society (604) 861-4788 or Ron Westlake at the City of Kelowna	**Victoria** *Contact:* Glenn Milbury Capital Regional District (604) 388-4421	

**For further information on backyard/neighbourhood composting contact the City of Vancouver's Compost Hotline (604-736-2250) or the B.C. Environment Recycling Hotline at 1-800-667-4321.*

5.0 CENTRAL COMPOSTING

A certain portion of residential households may be either unable or unwilling to compost their food and yard wastes, and there will be certain types of organics that will continue to enter the waste stream even with a high participation rate of backyard composting. For example, wastes such as meat, fish and dairy wastes are generally not included in backyard composters and yard wastes during peak seasons can exceed the capacity of a backyard compost. In addition, there will be a significant amount of organics from institutional, commercial and industrial (ICI) operations, which will require a higher level of management and infrastructure than single composting bins. Off-site composting involves the collection and transportation of organic wastes that will be composted at a central treatment facility. These facilities can handle a larger variety of organics than backyard composters and can be designed to compost large volumes of municipal and ICI wastes, thus diverting a significant portion of the waste stream from landfills. Central composting technology can range from small-scale yard waste management facilities to high technology integrated composting systems sold by engineering firms. The choosing of a system or equipment for composting requires a basic understanding of the technology and options relating to the collection, separation, pre-processing, active composting and final processing of organics in MSW. The following section is intended to be an overview of some of the major central composting options available today.

A. Sorting, Collection and Storage Options:

The local authority can encourage the source separation of organic wastes from other wastes to be composted at a central facility or they can be sorted after they have arrived at the facility, along with other recyclables. For municipal compost facilities to be efficient, the compostables must either be collected from the household establishment or convenient drop-off centres set up for transport to the main facility. There are many alternatives to choose from, depending upon the desired product quality, the public works budget, public preference and level of infrastructure in place to collect recyclables such as glass, plastics, tin and newsprint.

The separation of non-compostables can take place before (source separation), or after the MSW is collected and taken to a central facility (post-collection separation). Among the many advantages of source separation is the greater freedom from contaminants, particularly heavy metals. According to the Biocycle Guide to Composting Municipal Wastes, "...increasing emphasis on source separation at the household level has a direct effect on improving the trend to solid waste composting" (1989). This is because undesirable materials and heavy metals can be virtually eliminated from the composting facility and the product is, therefore, acceptable for a greater variety of uses. Compost derived from mixed municipal solid waste is often unacceptable for most uses because it is difficult to separate out the heavy metals and other toxic and visual contaminants before the refuse is composted. "Some of the most difficult metal-rich contaminants to remove are household dust, which can have a high lead content, staples, wine bottle caps and batteries" (Anon., May 1991).

For ensuring a high quality compost, source-separation of organics for central composting or backyard composting are considered to offer better alternatives because of significantly lower levels of heavy metals and other contaminants. According to Tom Watson of Resource Recycling "...plastic and other synthetic waste materials do not degrade in the same manner as biological material and the types that are degradable can release toxic substances, rendering compost unsuitable and unmarketable for many agricultural uses" (Watson, 1990). As well, markets have also been hampered by visible contaminants such as pieces of glass and plastic that will inevitably end up in mixed municipal waste compost.

From a technical aspect, mixed MSW compost sorted at a central plant requires mechanical equipment for the segregation of compostables from non-compostables as well as a number of other operations. Examples are; size reduction via hammermills and grinders, air classification to settle out heavy vs. light particles, and screening to separate the particles into two or more size groups. Source-separated organics on the other hand, do not require as much processing prior to the composting stage. The separation of the organic fraction by individuals may be viewed by some as an additional burden. However "...if a waste management system does not incorporate source separation, the ultimate objective of waste reduction will never be realized since the average individual is not consciously participating" (Foster, 1990).

5.1 Source-Separation Systems for Organics:

5.1.1 Collection and storage of organics on-site:

The first stage of source separated composting is the collection of organic waste on-site in the house or work area. Collection of food waste within the house must be easily accessible to kitchen and work areas and designed so that the contents can be removed to storage on a regular basis. According to Airite Ltd., who was recently involved in a pilot project to collect and compost organics in Powell River, B.C., "regular participation and maximum recovery of organic wastes are directly dependent on householder convenience and program acceptability" (Airite Ltd., 1990).

Participation of institutional and commercial sectors will also depend to a certain extent on the collection system used on the premises. For example, food wastes in restaurants will require visible and functional bins to collect organics, both indoors and outside. There are a number of plastic bags, bins and other commercially available containers that would provide sufficient storage of the material until it reached the composting facility. A small container can be used in a kitchen or dining room with material being transferred to a larger, outside container periodically. Plastic liner bags can also be used within kitchen containers to receive food wastes. The bags are then

be removed and replaced when full, the full bags stored in the outside receptacle. This system may be neater, but it generates more waste and may cause visual contamination if the bags are not removed from compost. As well, there is growing concern about the accumulation of bio/photodegradable plastic in the soil over time due to its chemical breakdown and possible release of toxins into the soil, so some form of debagging system is required. The reusable plastic tub without bags is an option for collecting kitchen scraps. Less waste is generated in terms of plastic, but the need to wash the container regularly may make it less attractive than the plastic bag. For the collection of both yard and food wastes, one study found that householders continue to use plastic bags for kitchen food waste and place them in their plastic wheeled cart along with loose yard and garden waste.

5.1.2 Source-separated bag system:

In Powell River, B.C. a pilot project was run to test the collection and composting of food and yard waste from approximately 300 households along with a number of restaurants and institutional kitchens. In the program's eight-month trial, material collected was processed and composted in an in-vessel system (see section 5.9) for food wastes and windrows for yard wastes. Collection kits were distributed to all participating households. The kits, provided by First Brands (Canada), consisted of a kitchen container, two packages of recyclable green bags, one package of blue bags and an information pamphlet. The green bags were for use in the kitchen container, and the blue bags were used for setting out at the curb. Household collection was synchronized with the regular garbage collection schedule at one pickup per household per week. Of the participants surveyed following the pilot project, 80% thought the collection kit was excellent (Airite Ltd., 1990).

A variety of "wet" materials could be included in the bags destined for the in-vessel composting facility. According to an information pamphlet put out by Airite Ltd. to Powell River residents, things that should not be included are:

- all non organics such as glass, metals and plastics
- any facial tissue, paper towelling or paper napkins that have been used to absorb paints, turpentine, motor oils, antifreeze or other chemicals that are considered a hazardous waste
- any other type of paper waste (besides paper towels, tissues, coffee filters...)

Items that could be included in the wet bins being collected for composting at the Airite Ltd. facility were any type of food waste including fruit and vegetable parings, eggs including the shells, meat, poultry, and fish, coffee grounds and filters, tea bags, and leftover foods. As well, certain types of waste paper such as household "wet" papers like facial tissue, paper towelling and table napkins could be included in the wet bins of homes and restaurants. Additionally, commercial washroom paper towels can be composted along with food waste in the Airite facility. However, it should be noted that mixed waste papers with printing inks and dyes may render compost unacceptable in terms of heavy metal content and also may be incompatible with commercial dry recycling programs.

5.1.3 Wet/dry collection

These systems are fairly common in parts of Europe and have been tested in some Ontario municipalities. Wet/dry collection systems consist of two stream, three stream, or variations thereof to separate MSW at the source. In two bin systems, MSW is sorted to emphasize either the compostable or the recyclable fraction. Generally, one container is used for "wet" materials such as food waste, yard waste, disposable diapers and soiled paper, and a second container holds the dry fraction of the waste (Watson, 1991). The inclusion of substances in the compost bin that may contain high levels of heavy metals (ie. ash from coal or batteries) will affect the marketability of the end product and, as well, the quality of recyclables may not be optimum if non-recyclable "dry" refuse is commingled throughout the bin. Three bin systems, on the other hand, include a separate bin for garbage so that the quality of the compostable wet and recyclable dry fractions are not jeopardized. In addition, three bin systems are thought to be more valuable in terms of changing the behaviour of waste generators because the separation of recyclables from garbage is required, as well as the segregation of the compostable fraction of waste (see Table 3).

Table 3

Comparison of Methods for Source Separation of Compostables

SYSTEM	ADVANTAGES	DISADVANTAGES
Two Bin Systems	- greater flexibility	- two-stream systems may be subjugating people to poor working conditions
	- collection times & costs would be much lower at the sorting plants than with a 3 stream system	- inferior in terms of the end product
	- easier to implement in multi-unit dwellings and commercial settings	
	- may recover more organic waste than three bin systems (Guelph pilot project)	
Scenario One		
BIN 1 (Scrap metal;ferrous, plastic & glass containers)	- high quality of recyclables (little contamination, high marketability) in BIN 1	- residue in BIN 2 would not be much cleaner than residue obtained from the separation of mixed MSW centrally
BIN 2 (all the rest, except bulky, hazardous and other unacceptable wastes)	-removal of BIN 1 recyclables more complete than what could be accomplished at a central facility	
Scenario Two		
BIN 1 (Compostable material)	- emphasis is on the compostable fraction rather than the non-compostable; therefore, the quality of BIN 1 would be virtually free of plastics, glass etc...	- the quality of the recyclables is not as good as in the first scenario because of the inclusion of non-recyclable residue
BIN 2 (glass, metal, plastic and non-recyclcables)		-decision to be made as to which biodegradable wastes should be designated as compostables
		-people may not gain a real sense of recycling because they throw recyclables in with the rest of the dry garbage

Three Bin System		
BIN1(compostables)	-high quality of recyclable and compostable fraction	-additional burden on waste generator (household) and on collection and transport
BIN2 (recyclables ie. glass, metals, plastic)	-perhaps the most valuable in terms of changing public behaviour	- decision has to be made as to which biodegradable wastes should be designated as compostables
BIN 3 (remaining)		

Sources: Goleuke and Diaz. May 1991. "Source separation and MSW compost quality." Biocycle. Vol 32, No 5 ; Watson, Tom. April 1991. "The latest European import: wet/dry collection systems." Resource Recycling. Volume 10, No. 4: pages 19-23.

Two bin systems offer a greater flexibility than three-bin systems and may be easier to implement in multi-unit dwellings and commercial settings. One study in Guelph found that a simple two stream system recovers twelve (12) percent more organic waste than the three-stream system because the third bin for the garbage stream in the latter system has an appetite for compostables and recyclables. Pilot projects in Guelph are experimenting with both two-bin and three-bin systems.

A variation of the wet/dry system is the use of two bins for separation of three different waste streams. In certain areas of Germany, the wet fraction, bio-waste, and the disposal fraction are collected in a split container, generally with the bio-waste in the left half and the disposal fraction in the right. The container is a rolling cart and designed with a metal nub that allows the collection truck loading mechanism to position and empty the bin into separated compartments. A second bin is used for commingled recyclables (Scheinberg and Smoler, 1990). A probable advantage of this system is a reduced work load for collection crews since the heavy fractions are lifted simultaneously into the vehicle by the loading mechanism. An added option is that the divided container can be adjusted by moving the partition allowing for different ratios of garbage and organics.

Collection Equipment for wet/dry systems:

The separated components can be collected simultaneously using a compartmentalized collection vehicle, as is done in many of the blue box programs for recyclables. Alternatively, the separated components can be collected separately by different vehicles, or on different days by having organics picked up on one day and other recyclables and/or refuse on another. Collection of organics, particularly food wastes and certain industrial wastes, requires a vehicle that is water-tight with a compartment that is easy to clean. As well, any bins placed at the curbside/backyard for organic wastes should be animal-proof and water-tight to prevent excess moisture from soaking the contents or leaching nutrients from the organics.

5.1.4 Separate collection of yard and garden debris:

Yard and garden debris generated by householders and municipal properties may be targeted for collection separately from other organics. In fact, many cities in the U.S. and some Canadian municipalities are currently collecting yard and garden debris from various sites to be centrally composted. These organics can be collected from the site either loose or in some kind of container. Equipment for loose collection of yard and garden debris includes mechanical scoops and vacuum machines. The most commonly used mechanical scoop is the front end loader but unless a special "pincer" type bucket is used, the loaders are not particularly efficient. There are also self-contained units

available (ie. the Kolman-Athey Force-Feed Loader) which use a series of paddles to scoop material onto a conveyor which then empties into dump trucks. Vacuum equipment for sucking up leaves and other loose debris can be purchased either as self-contained units, which include both the vacuum machine and a self-dumping collection unit, or vacuum loaders which do not include a collection unit but load into enclosed containers.

Other yard and garden waste collection programs utilize containers which are either manually or mechanically loaded into a collection vehicle. Containers such as plastic bins or wheeled containers have a number of advantages over bags for collection of yard and garden debris. First, they are reusable, and therefore do not require repeat purchases of the single-use paper or plastic bags. Second, they come in a variety of sizes ranging from 136 to 1818 litres (30-400 gallons), depending on the volume of waste to be collected. In addition, these plastic containers are usually water-tight and animal proof and, thus, programs collecting yard and garden debris can be expanded to include food wastes if desired. A disadvantage of the reusable container system is that yard waste sometimes exceeds capacity and bags must be used for the overflow.

The type of bag used to collect the yard debris will influence the remainder of the processing steps. For example, with both standard plastic and photodegradable or biodegradable bags for yard waste collection, some type of debagging device is needed to remove them from the organic material either before or after the screening process because the "degradable" bags often decompose at a rate slower than that of composting process. In this respect heavy duty paper bags are more desirable for temporary storage of yard waste because they are compostable at approximately the same rate as the leaves and other yard debris and, therefore, do not have to be removed.

A comparison of three different methods of leaf collection in Bristol, Connecticut (pop. 60,000) revealed that bag collection is much more cost-effective than bulk collection such as vacuum and front-end loader collection. According to the Biocycle Guide to Yard Waste Composting, the cost was $106.33/ton U.S. for vacuum collection, 95.80/ton for the front-end loader method and $55.28/ton for bag collection (Biocycle 1989 b).

5.1.5 Automatic collection techniques for containers:

Containers of organics can often be very heavy, as in the case of wet yard waste and kitchen waste, and can present problems to collection crews who must empty them into trucks. Automated collection vehicles can be equipped with a mechanism to grab the organics collection container and empty it into the compactor truck, much like the system often used to collect regular garbage. In a review of European food waste collection and composting programs in Biocycle, three major types of automatic collection vehicles were noted (Scheinberg and Smoler, 1990). The first is a truck with two lift mechanisms which empty independently of each other, allowing bins to be handled by two separate collectors. Secondly, there are also vehicles equipped with three (3) lifts for containers that operate simultaneously. Although efficient at maximum capacity, the three lift system is not favoured by handling crews because it requires them to synchronize loading and it was more convenient to empty the containers by hand into the collection vehicle. A third type of automatic collection is the use of horizontally or vertically divided compactor trucks with two discrete compartments. One bin is for the organic waste and the other is for the disposal fraction, so pickup can be done simultaneously. However, with most European two-bin systems, the organic fraction and the garbage are collected on alternate weeks, thus the collection costs do not increase except through the initial purchasing and distribution of the bins.

5.1.6 Recycling centres or drop boxes:

Recyclables including organics can be brought to the central facility or municipal collection bins. Advantages include reduced costs for collection because there are significantly fewer pickup points if the waste generators were involved in transporting some of the waste. As well, equipment needs such as trucks required for material pickup are greatly reduced. According to the Department of Ecology in Washington State, "...where larger volumes of recyclable materials are generated, primarily in urban areas, curbside collection is cost-effective. Where volumes of recyclable materials are smaller, primarily in rural areas, the cost-effectiveness of curbside collection decreases" (Washington State Department of Ecology, 1989). As well, the cost-effectiveness of programs for collecting and

processing organics depends not only on the waste quantity, but on the technology involved in composting, type of organic material, distance from markets, facilities available, and the amount of self-hauled waste. As shown by the municipality of Oak Bay in the CRD, composting self-hauled yard waste is considerably less expensive than disposal in the local landfill (see section 7.3).

This type of collection for organics and other recyclables may, however, be perceived as "too inconvenient" to waste generators and participation may not be as high as desired. It should be noted that a continuous public education program is required to generate interest and participation in yard waste drop-off programs. According to Biocycle, the use of a citizen dropoff program in place of organized collection during periods of low yard waste generation should be considered as an option (Biocycle, 1989 b). With regard to kitchen wastes, however, the hauling by the householder would have to be carried out quite often due to the regular generation and putrescible nature of the waste, and in this case, curbside collection and/or backyard composting may be more advantageous.

5.2 Post-Collection Separation Systems:

This approach to producing compost involves the separation of the compostable from the non-compostable fraction after collection from the household or institutional/commercial establishment. The facilities that are designed to process mixed MSW are referred to as resource recovery facilities (RRF) and not composting plants, a term reserved in this paper for the recycling of source-separated organics. This distinction is important to make because mixed MSW is so heterogenous and, thus, requires a different and more involved preprocessing machinery configuration than is needed for source-separated organics. Usually the sorting of mixed MSW is done mechanically, using equipment for size reduction, screening, air classification and magnetic separation along with some manual sorting.

Air classification is one method to sort materials mechanically within a resource recovery facility. Materials of different size, density and/or air resistance are separated in a moving column of air. For example, particles with a large drag-to-weight ratio are suspended in the air stream, whereas those with a small drag-to-weight ratio such as metals, glass, fines tend to settle. Existing air classifier designs can be broadly classified into vertical, horizontal and inclined (Ontario MOE, 1990). Magnetic separation is a simple way to recover ferromagnetic material in mixed MSW; however, as a general rule, magnetic separation is performed on shredded MSW or after some other processing step to homogenize all of the material or to concentrate the metallic portion, such as by initial screening (Alter, 1983). Screens of various kinds are often used as separation devices in both resource recovery plants and composting plants. Little preparation is required at the household/ICI level before the collection of the combined recyclables/refuse except the separation of hazardous wastes by preventing batteries, pesticides etc., from being placed in the bin destined for the RRF.

Post-collection separation systems can be seen as advantageous in terms of participation rates and maximum resource recovery. In areas with a rural population base that do not have the infrastructure in place to collect recyclables at the curb, post-collection separation facilities may be a viable way to pick out recyclables and produce compost, although the quality will depend on the type and extent of preprocessing. According to the Dutch experience, systems which involve the composting of mixed household waste without any preparation produce compost with high metal levels after inerts are sieved out (see Table 4). The metal concentration can be reduced further by separating the mixed waste into fine and large fractions and then composting the fines. When mixed household waste is shredded and inerts such as metals, plastics and glass are removed, the metal concentration drops further. However, the lowest metal concentrations are found with systems which involve the composting of source-separated organics. Column E figures are the B.C. Regulation Code 1 metal limits for MSW compost. From the table it is apparent that mixed MSW compost has metal levels exceeding the B.C. Code 1 limits significantly, whereas, source-separated compost meets the limits in all but one category (lead), which is marginally exceeded.

Table 4

Heavy Metal Content of Dutch Compost

Heavy Metal Concentration (mg/kg dm)

Heavy Metal	A	B	C	D	Limits
Zinc	1700	800	520.0	230	<315
Copper	600	270	100.0	50	<100
Nickel	110	35	25.0	10	<50
Cadmium	7	2.5	1.8	1	<2.6
Lead	800	700	420.0	160	<150
Chromium	180	70	40	30	>210

A Composting of mixed household waste without preparation. Inerts sieved out after composting.

B Mixed household waste is separated into fine and large fractions, and the fine fraction is composted.

C Mixed household waste is shredded and inerts such as metals, plastics and glass are removed. The remaining waste is composted.

D The organics are separated at the source and subsequently composted.

Limits B.C. MOE Code 1 metal limits (draft 4)

*source: R. Cave and Associates Ltd. "Composting of organics in the waste stream - a feasibility study for the City of Guelph"; *B.C. MOE "Draft regulation for the production and use of compost from municipal solid waste for British Columbia."*

B. Pre-processing:

After collection, both source-separated organics and mixed MSW require preparation prior to composting. The pre-processing of source-separated organics may involve separation of different organic fractions, particle size reduction, mixing of different substrates, and removal of plastic bags from the organic fraction before the active composting stage. Pre-processing for mixed MSW usually involves a series of separation steps to recover glass and ferrous metals, paper and other materials for refuse-derived fuel (RDF) as well as mechanical preparation of the biodegradable fraction for composting. This section focuses mainly on pre-processing techniques for source-separated organic composting operations, although many of the same processes are used in RRFs.

5.3 Separation/Initial Screening:

Different types of organic waste may require different levels of processing prior to composting; therefore a separation step must be carried out after collection. For example, in some yard waste operations, an initial screening of material is done to separate woody material from fines such as grass and dirt. The Cedar Grove Composting Company in Washington State (see section 7.5) utilizes a disc screen to separate materials for grinding in the hammermills. This initial separation reduces the amount of material that must go through the grinder and thus, reduces the operating costs of this piece of machinery.

5.4 Particle size reduction:

Reducing the particle size of the organic material is an important factor in the composting process for a number of reasons. Most importantly, grinding, shredding or chipping the wastes will increase the surface area and give microorganisms greater access to the material, thus decomposition will occur more rapidly than it would with larger sized particles. Also, utilizing size reduction equipment greatly reduces the volume of incoming material thus lowering the space needed for windrows. In addition, the compost material is made relatively homogenous by the reduction in particle size, thus facilitating easier handling and better response to moisture control and aeration.

Particle size reduction is not always necessary with composting of source-separated organics. For example, leaves are not always shredded prior to composting because the particle size is already small enough and also because they are difficult to handle in a grinder while wet (City of Vancouver, 1991). For larger and more heterogenous organic materials however, some sort of size reduction is usually necessary prior to composting. It is important that materials are not ground too finely or compaction may occur, resulting in improper aeration when the material becomes wet. The ideal particle size for woody material, straw, wood shavings and like substances is a centimetre or less. However, paper and vegetable trimmings should not be reduced to a particle size less than between 2.5 cm and 5 cm to ensure proper aeration (Goleuke, 1977). The desirable particle size also depends upon the composting method. For example, material to be composted in a mechanical digester may be ground much more finely than that which would be windrowed.

Size-reduction equipment generally includes shredders, grinders and chippers (see Appendices A and B). In choosing a system it is important to know the type and approximate volume of materials to be processed because equipment varies in throughput capacity, durability and suitability. Shredders are commonly used in pre-processing kitchen waste and for reducing the particle size of yard wastes. As well as reducing the volume of incoming material, shredding systems can be used to blend various types of organics prior to composting or after the process is complete. Types of shredding systems include tub grinders, hammermill systems, with vertical or horizontal type shaft, and slow speed shredders. In an evaluation of grinders in Florida yard waste composting projects, it was found that small grinders were not durable enough to handle larger pieces of wood and the hammers needed to be replaced or resurfaced frequently. Thus, grinders were found to be expensive in terms of materials, labour and lost grinding time (Barkdoll and Nordstedt, 1991). The lack of a shredder, or possession of an inadequate shredder has been one of the more frequently encountered problems in yard debris compost projects (Ontario MOE, 1990).

The most widely used type of shredding system for yard wastes is the "tub-grinder, a hammermill type shredder with a rotating cylindrical hopper" (Glenn, 1990 a). Tub grinders are available either as self-powered units or for use with a power take off (PTO) system, the former being considerably more expensive to buy. One self-powered commercial unit utilized by Oak Bay municipality in the Capital Regional District retails at about $95,000 Cnd.. For particle size reduction of kitchen wastes, hammermill grinders or shear shredders are used, as tub grinders are not suited for the high moisture content in food wastes. Often mixing kitchen waste with other materials is sufficient to begin efficient composting because these wastes are highly putrescible and break down fairly quickly.

An auger system grinder manufactured by Iggestund uses fixed, rotating augers to reduce the particle size of materials which can be adjusted by the pocket depth on the augers and by the closeness of the knives to augers. According to Biocycle, the particle size of material put through the auger system was not as fine or as uniform as that by tub grinders; however, the augers needed to be replaced much less frequently than the hammers in the tub grinders. As well, Iggestund augers rarely become damaged by metal contaminants which could cause very expensive damage to high speed tub grinding equipment. Iggestund auger systems retail for about $300,000 Canadian.

Brush and wood chippers can be used to reduce the volume of woody material to be composted or set aside as mulch. Chippers have an infeed capacity of between 39 and 123 centimetres. Some are powered by power take-off (PTO) and others come with self-contained power (Glenn,1990 a).

Particle size reduction, if not done before the composting process, is done afterwards to ensure a consistent product. For example, the City of Vancouver's pilot leaf windrowing project utilizes a tub grinder for size reduction of material after the active composting step. Compost with a consistent structure and nutrient level is proven to be more marketable than compost containing large particles of material.

5.5 Mixing Equipment:

A certain ratio of carbon to nitrogen in the material (C/N ratio) is required for microbial decomposition, whether the organic material is in a backyard composting bin or a large scale facility. A ratio of about 25 to 30 parts carbon to 1 part nitrogen is considered optimum in the starting material. A higher C/N ratio slows the composting process and a lower one increases nitrogen loss (Barkdoll and Nordstedt, 1991). Nitrogen-rich organics include animal manure, kelp meal, fish meal, digested sewage sludge, weeds, green glass clippings, fruit and vegetable scraps, blood meal, and legumes (B.C. Ministry of Environment, 1983). Organics rich in carbon include leaves, branches, hedge clippings, pine needles, hay and straw. Highly carbonaceous material includes sawdust, wood chips and newspaper (see Table 5).

Table 5

C/N Ratio of Various Wastes

Material	Nitrogen	C/N Ratio
Night soil	5.5-6.5	6-10
Urine	15-18	0.8
Blood	10-14	3.0
Animal tankerage	–	4.1
Cow Manure	1.7	18
Poultry manure	6.3	15
Sheep Manure	3.8	-
Pig Manure	3.8	-
Horse Manure	2.3	25
Raw Sewage Sludge	4-7	11
Digested Sewage Sludge	2-4	-
Activated Sludge	5	6
Nonlegume vegetable wastes	2.5	11-12
Mixed grasses	214	19
Potato Tops	1.5	25
Straw, wheat	0.3-0.5	128-150
Straw, oats	1.1	48
Sawdust	0.1	200-500
Wood	-	700
Dried Leaves	-	60

Grass Clippings	-	19
Paper	-	170
Fruit Wastes	-	35
Humus	-	10

source: Golueke, C.G. 1977; B.C. Environment. 1983. Garbage is Resource Full.

To achieve the correct ratios of nutrients throughout the compost pile, thorough mixing of organics is required. Shredders or turning equipment can be used to do the initial mixing of materials. If required, specialized mixing equipment is available for more complete mixing such as the case where sewage sludge must be blended with bulking agents. Mixers are available as either batch type systems, or continuous feed units. Calculating the best proportions of materials for composting can be done by dividing the added C/N ratios of two or more materials by the number of units involved. For example, the C/N ratio of two buckets of dried leaves and three buckets of grass clippings is 35:1 (too high). Using the numbers in the table below, the calculation is as follows:

Units of material	C/N Ratio		(times no. units)
2 dried leaves	60:1	(x2)	120:2
3 grass clippings	19:1	(x3)	57:3
			177:5

**source: B.C. Ministry of Environment, 1983*

The added C/N values are divided by the number of units to equal 35:1, a C/N ratio that is too high for optimum decomposition and must be decreased by adding more grass clippings, rotted manure or vegetable wastes.

5.6 Bag Breaking Methods:

When plastic bags are utilized to collect yard waste or kitchen scraps, the contents must be removed from the bags either at the time of collection or at the compost site. Mechanical bag breaking or tearing units that separate the organics from the bags prior to shredding and active composting can be used, but these are costly in terms of capital expense (Biocycle 1989 b). Manual debagging can also be done, but it is often a slow labour-intensive process. According to the Michigan Yard Waste Composting Manual, there are three techniques for manual debagging: cutting with a hand-held knife, throwing the bag against a cutting edge attached to the compactor hopper, and ripping the bag open by hand. Mechanical debagging can include the use of machines that slice the bags for separation by a trommel or a slow speed shredder. Specialized windrow turning equipment can also be used to remove material from bags but they must still be manually removed from the teeth of the machine.

C). **Major Methods of Central Composting:**

Four common compost technologies for central composting include; windrows, static aerated piles, in-vessel systems and hybrid types, which combine two or more of the other technologies. The method chosen will depend upon a number of factors ranging from the characteristics of the material to be composted to the level of mechanization desired/afforded by the operator, availability of land, etc.... Because of the large quantities of organic waste to be decomposed, off-site composting should employ aerobic (in the presence of oxygen) reactions to shorten the composting period and reduce the size of composting plants (Polprasert, 1989). Composting can be done informally for some organics such as leaves and shredded brush with only periodic aeration in a windrow system. However, addition of grass and other highly putrescible organics such as kitchen waste in large quantities requires that the rate of decomposition be sped up. This can be done by providing conditions optimum for micro-organisms including; correct moisture level, proper supply of oxygen, material with a large surface area to volume ratio, and insulation.

The following five methods of composting use different levels of technology in an attempt to optimize the conditions to allow for the decomposition of organics into compost. It is important to note that each system has both advantages and limitations with regard to throughput capacity, required treatment time and flexibility to accept different feedstocks.

5.7 Windrow Method:

This is the most commonly used method for composting yard debris such as leaves and tree trimmings. A windrow is simply an elongated pile of material with a more or less triangular cross-section. Aeration of the pile can be achieved through some sort of mechanical turning, by forced aeration (see section 5.8), or a combination of the two. Turning can also be done manually, but it is considered impractical with volumes larger than one or two cubic meters (Ontario MOE, 1990). Uniform decomposition as well as pathogen destruction is best achieved by turning the outer edges into the centre of the pile at each turn. However, when this cannot be accomplished the frequency of turning can be increased. As well, turning should be more frequent than the regular schedule when the moisture content of the pile is too high to minimize development of anaerobic conditions. In areas that receive heavy rainfall, it may be necessary to cover the windrows so they do not become too soaked; however, the cost of this may be prohibitive for certain operations. Alternatively, maintaining a triangular or dome shaped windrow is effective for shedding excess rain or preventing the accumulation of snow in the winter (Golueke, 1977).

The equipment used for turning the windrow to achieve aeration varies from front end loaders or bulldozers to specially designed turning machines. Loaders, although inexpensive compared to turners, have a tendency to compact the composting material and are comparatively inefficient (Goleuke, 1977). For wastes such as fish products that require more frequent turning (twice daily) for odour minimization, specialized windrow turners would be suited for the task.

There are three basic types of windrow turners. "The most commonly used have a series of tines that are placed along a horizontal drum to move through the composting material, turning, mixing, aerating and reforming the windrow as it moves along. A second type utilizes a moving, elevating face, equipped with sharp teeth to turn the pile. The other system uses a series of paddles to move through and work the material" (Glenn, 1990 b). These windrow turners are either self-contained units that straddle the windrow, worth in excess of $100,000 U.S., or are powered by a PTO and either pushed or pulled by a tractor for a purchase price of under $50,000 U.S.. For example, Wildcat compost turners are available in 15 sizes with capacities from 136 metric tonnes per hour to more than 2,358 metric tph. The Scat Model 483B compost windrow turner handles up to 2720 metric tph and has inversion control to move material from the outside of the windrow, depositing it in the middle of the new windrow assuring complete composting of the entire windrow. For more information on windrow turners, see Appendices A and B.

Unlike the turned windrow method described above, static windrows rely on the natural diffusion of oxygen into the pile. However, this process does not provide conditions to allow MSW or yard waste compost to meet regulations because, in the absence of turning, the entire pile may not be aerated or may become too wet, leading to slow and odorous anaerobic conditions.

MANUFACTURERS OF WINDROW TURNERS:

A-1 Environmental, Brown Bear Corp., Eagle Crusher Co. (Cobey), Kolman-Athey, Lindig Manufacturing, Resource Recovery Systems of Nebraska, Inc., Scarab Manufacturing, Scat Engineering, and Wildcat Manufacturing Co. (see Appendix B).

DISTRIBUTORS IN B.C.:

Gemaco Sales in Kelowna, Rollins Equipment in Vancouver (see Appendix A).

VENDORS:

For complete turned windrow systems include Agripost, Inc.; Ecological Technologies (ECOTECH), Inc.; Environmental Recovery Systems, Inc.; Compost Management Associates Ltd. (see Appendix C).

5.8 Static Aerated Pile Method:

The static aerated pile method is a windrow composting process in which aeration is accomplished either by forcing (injecting) or drawing air through the compost pile as an alternative to frequent turning to provide aeration. The material can be stacked on slotted or perforated floors connected to a fan. The floors are first covered with a layer of bulking agent such as wood chips or finished compost, the organics are added, and then a topping layer of finished compost is applied to provide insulation. A major difficulty with this system is diffusing the air through the entire pile, especially with wastes characterized by a large particle size, large and varied particle size distribution, high moisture content, or those with a tendency to clump (Ontario MOE, 1990). Other problems include the formation of channels in the pile which allow forced air to short-circuit through them, causing excessive drying due to evaporation of moisture near the channels. These situations require the occasional turning of compost piles (Golueke, 1972).

Despite these problems, the static aerated pile method has been used extensively in composting sewage sludge in the United States (Diaz and Golueke, 1989). The approach is most effective with wastes "...that are relatively uniform in particle size and whose particle size does not exceed 3.8 to 5 cm in any direction" (Ontario MOE, 1990). Granular particle size distribution of the material and correct ratios of bulking agent are extremely important in maintaining proper air flow in static aerated pile composting. Other materials that could be successfully composted using this method include yard waste such as lawn clippings and branches and dewatered food wastes. Although vendors maintain that because the system is aerated, odour problems are usually negligible, exhaust air may be passed through a biofilter where microorganisms absorb and break down any odour causing compounds that may be present.

VENDORS:

Buhler-Miag, Inc.; Daneco; WPF Corporation (see Appendix C).

5.9 In-Vessel Method:

This method consists of a confined compost process involving mechanical mixing of compost under controlled environmental conditions. In-vessel, or enclosed vessel, systems fall under three main categories: 1) rotating drum; 2) horizontal (rectangular/cylindrical) or vertical (silo) and; (3) channel. The main advantages of in-vessel systems over open systems (windrows, aerated static piles) are the shortening of the mesophyllic and thermophilic stages, a higher process efficiency and a decreased number of pathogens, resulting in a safer and more valuable end product (Sayag and Andre, 1987). As well, space requirements are generally less than that of other methods of composting. However, it is important to note that, despite claims by some vendors that their in-vessel system can produce compost in the reactor, all systems require windrowing for final stabilization. Disadvantages of the enclosed vessel

method include high capital and operational costs due to use of computerized equipment and skilled labour. The in-vessel method is increasingly being chosen by decision makers seeking a sludge management solution (Biocycle, 1989 a). In-vessel options for sewage sludge composting may be defined as systems which are under roof, mostly enclosed and easier to fit for "total" off-gas collection and treatment. The in-vessel composters are generally more automated than the open windrow or static pile systems. Common reasons for choosing in-vessel over other composting methods include:

1) Odour control
2) Space constraints at the site
3) Process and materials handling control
4) Better public acceptance due to the aesthetics/enclosure
5) Less manpower requirements
6) More consistent product quality

A marginally high tech in-vessel system consists of a "horizontal, rectangular tank equipped with an especially designed (sic) travelling endless conveyor belt mounted on wheels that move on tracks placed at the bottom of the tank" (Golueke and Diaz, 1990). The belt serves as a mixing device and the tank has a perforated bottom for continuous or intermittent forced aeration. Retention time is approximately one week before the composting material is windrowed for curing.

VENDORS:

American Biotech; Purac Engineering; Recomp etc., (see Appendix C).

5.10 Other:

5.10.1 Hybrid

Basically this category involves a combination of the above three methods of composting. The most common type of hybrid system involves "...the initial stage of the compost process to take place in a reactor and all succeeding stages in windrows ... in practice, almost all in-vessel designs can be classified as hybrids" (Ontario MOE, 1990). One example of a hybrid plant is in the City of Guelph, Ontario, where a 10-metric-tonne-week pilot plant was constructed to compost kitchen and yard waste. A partial description of the hybrid system is as follows: "The composting system is a hybrid between a static aerated pile and an in-vessel reactor. Three primary cells (3m x 3m) and three secondary cells (4.5m x 3m) are normally loaded to a depth of 1.2m. Material is kept in the primary cells for three weeks and then five to six weeks in the secondary cells. The contents of two primary cells are used to fill a secondary cell. After week nines, the fresh compost is unloaded from the secondary cell, screened and windrowed for another five weeks for stabilization" (Hoornweg, Otten and Wong, 1991).

5.10.2 Dutch Tunnel Technology

According to Rutgers University Professor, Mel Finstein, composting systems should be flexible and modular and able to accept different feedstocks (UMA Engineering Ltd., 1991). Dutch Tunnel systems for composting are modular, about 33 x 3 x 3 metres, enclose only the composting mass, and allow air recirculation with feedstock control of oxygen and temperature. There are 400 such systems in use worldwide, mostly for transforming various combinations of animal and plant wastes (horse manure, chicken manure, wheat straw, chopped corn cobs, cotton seed meal...) into a substrate for growing mushrooms. About half of the tunnels currently in service were built within the last few years and have computer-assisted biological process control via sophisticated management of ventilation. According to Finstein, the tunnel technology offers the best opportunity to reduce and control odours and dust in source-separated MSW and there appears to be few constraints to using tunnel technology in future MSW composting processes. However, such a system may be expensive in terms of capital and operation.

Although none are known to be operating in B.C. at this time, at least one of these systems is operating in Airdrie, Alberta by a company called Heritage Mushrooms. The tunnel system has been in operation since 1981 to provide a substrate containing essential compounds for growing mushrooms. Straw is the main feedstock placed in outdoor windrows where the composting process is initiated. Canola seed and chicken manure are also added as nutritional supplements to the carbonaceous material. Depending upon the season, the material in windrows are composted from between 3 weeks and 6 weeks before being transferred to the tunnels. The material in the tunnels is kept under strict process control, including aeration and nutrient addition, for an additional week before it is ready to be used as a substrate for growing mushrooms. This system was built and marketed by Double-T Equipment located in Airdrie, Alberta. Further information can be obtained by contacting:

Mr. Thomas, Double T Equipment
Box 3637
Airdrie, Alberta
T4B 2B8
ph: (403) 948-5618
fax: (403) 948-4780

D. Overview of Odour Control Technology in Composting:

The prevention and control of foul odours is a very important issue to be addressed in regard to composting operations because the lack of odour controls has caused some central composting facilities to shut down in the past (ie. Sussex County, New Jersey's aerated static pile composting facility). There are three major types of odour control treatments:

1.) bio-filters (ie. earth, compost)
2.) activated carbon
3.) chemical scrubbers

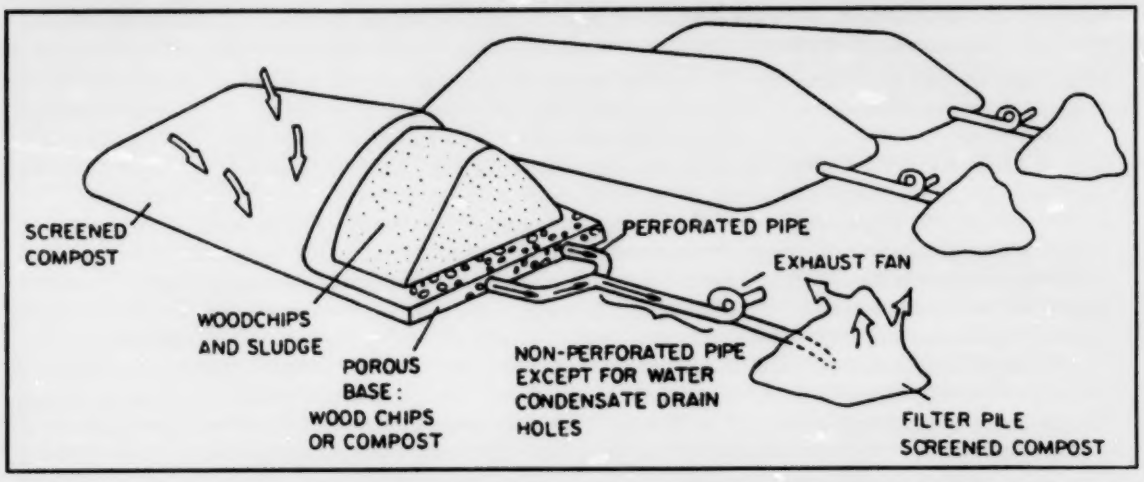
By passing gases from the composting mixture through a pile of screened compost (humus) or soil, odour control can be achieved. This technique is well-suited to the aerated static pile method of composting because a non-perforated pipe can be hooked up to the aeration pipes to draw gases out of the pile into the bio-filter (see figure 1). For further deodorization, the entire pile can be covered with a 30 cm layer of screened compost (Polprasert, 1989). Bio-filters have three characteristics that make them effective in reducing odour: physical absorption, chemical oxidation, and biological assimilation of the gases once they have adhered to the soil particles. The absorption capacity of bio-filters is said to be self-sustaining as long as waste loading environmental parameters including temperature, oxygen, carbon dioxide, and C/N ratio remain constant (Biocycle 1989 b).

Gases can also be scrubbed to reduce odours within a composting operation. Commercial products are available that use small droplets of chemical to wet-scrub odours out of gases. The wet scrubbing action dissolves organic solvents and other chemicals into the water vapour. It is important to note that high temperatures often prevent adequate solubility and therefore, gases must be cooled down to 26.6 to 32.2 ^{0}C before running through the scrubber. According to the inventor of the Quad Chemtact System for odour control, "There is no such thing as 100 percent odour control... we can, for example, scrub ammonia out of the gases. But it is still in the water" (Biocycle 1989 a,b).

In operations such as yard waste composting facilities where the capital costs of the above odour treatment technology would be prohibitively expensive or impractical, lower tech odour control can be practiced. Many odour problems can be either prevented or mitigated by maintaining proper conditions for microorganisms. For example, the composting of grass is often associated with foul odours because it usually sits in closed containers for a few days prior to arriving at the site. The problem can generally be overcome by mixing the grass with other materials as soon as possible and providing the necessary aeration for aerobic microbes. One facility in Michigan (SEOCRRA), which composts grass alone, uses a lime slurry and a masking agent to overcome odour problems (Glenn, 1990 a).

Figure 1

Aerated Static Pile Technology with Bio-filters



source: Polprasert. 1989. Organic Waste Recycling. Page 88.

The control of odour is one of the most critical elements of sludge composting besides pathogen kill and product stabilization. The first consideration in odour control should be the planning of the size and location of the site to provide necessary buffer zones between the facility and the public. Secondly, odour should be controlled by odour avoidance through proper aeration, control of temperatures, moisture level, porosity and mixing. Thirdly, all potential sources of odour should be identified and appropriately scrubbed by compost/earth filters, chemical towers, or aeration basins.

E. Final Processing:

Final processing is designed around the intended market use of the compost to eliminate material and oversize particles that would detract from the quality of the product. Final processing may consist of screening and/or grinding (shredding). Screens are used to remove debris such as rocks, plastic and glass so that compost can meet particle size requirements of compost users and foreign matter limits as stated in the Regulation for the Production and Use of Compost from Municipal Solid Waste in B.C.. For example, in the Regulation, type "SS" compost allows less than 1% by weight of foreign matter and it must be of a size that will not cause injury. A shredding/grinding process in conjunction with a screener allows the operator to reduce the size of any oversized material (Glenn, 1990). Oversized organic materials are usually fed back into the composting system, whereas foreign objects (glass, tin, plastic) can be either recovered or landfilled.

There are two main types of screens; rotating, or trommel screens and vibrating, or flat bed screens. Trommel screens are advantageous because they avoid "blinding", which is the covering of screen perforations by oversize particles or plastic, and often occurs using horizontal screens (Goleuke, 1977). However, some people in the composting business prefer the vibrating screens to the trommel screens because they are simple to operate, have higher throughput rates, and efficiently reject foreign items such as plastic (Matear, 1991). According to Suzanne Leger, the Marketing and Sales Representative of Cedar Grove's yard waste composting operation in Washington, the tendency of the screens to "blind" depends upon both the angle of the screens and the screen size (see section 7.5). Blinding of the screen is also dependant upon the moisture content of the material and the nature of the foreign

matter contained within the compost. Material that is too wet, or that has a high percentage of foreign matter like plastic, tin, glass, etc., will impede efficiency in most screening operations.

There is also combined shredding/screening equipment to reduce the particle size of material. These combined units are said to be appropriate for yard waste composting projects that use front end loaders to turn the material in windrows. The capacity of shredder/screening equipment ranges from 11.5 to 306 cubic metres with a price range of about $15, 000 to $170, 000 U.S. (Glenn 1990 b).

6.0 CO-COMPOSTING

Co-composting, very simply, can be described as the composting of a mixture consisting of two or more types of wastes. Examples of such mixtures are manures and crop residues, manures and MSW, industrial food wastes and MSW and most commonly, MSW and sewage sludge. Co-composting usually pairs a material with a structural, nutrient or moisture content complement, so that close to optimum conditions can be achieved. For example, yard trash, except for grass clippings, is rich in carbon and poor in nutrients such as nitrogen and phosphorus and, therefore, it will compost slowly. However, by composting yard wastes with other wastes such as animal manures, fish wastes or sewage sludges, the nutritional status of yard waste is increased to accelerate the composting process. The system usually proposed and applied in co-composting is the aerated static pile with shelter for control over the release of emissions, or in-vessel composting as is used in sewage sludge composting in general.

6.1 MSW and sewage sludge/septage:

There are two major directions involving the co-composting of sludge and other municipal waste: (1) the increasing popularity of the use of yard waste as a bulking agent for sludge composting (at a ratio of about 3:1 yard waste to sludge); or (2) the integration of an unspecified amount of sludge with other feedstocks at a municipal composting facility.

(1) The practice of using yard waste as a bulking agent in sludge composting operations is documented as working well, both biologically and at a waste management level, because the practice of landfilling of sludge is being actively discouraged or banned in many U.S. States (Goldstein, 1991). Although there are concerns expressed by compost marketers and regulators about contaminating a clean material with sewage sludge, thus making the distribution of the finished product more complicated, sludge composting projects using yard waste have seen more advantages than disadvantages in many U.S. operations. It is to be noted, however, that compost quality requirements in many U.S. jurisdictions are considerably less stringent than European or Canadian criteria.

(2) The addition of sludge to MSW, either mixed or organics only, is usually done, not so much to treat the sludge, but to add moisture to the mix and enrich the MSW with nitrogen and phosphorus.

Examples of Equipment Used for Co-composting

The following information was condensed from articles in Biocycle entitled "Co-composting sludge and yard waste," by Nora Goldstein (January, 1991) and "Septage dewatering, treatment and composting," by Todd Williams, M. Gould and T. Callihan (April, 1990):

Bloomington, Indiana - For the last eleven years the wastewater treatment plant in Bloomington has operated a two dry ton/day windrow co-composting facility. The initial mix for composting is one part sewage sludge to three parts yard waste to one part sawdust (as an absorbent). The sludge type is raw primary or secondary with 12% solids. A vermeer self-feeding wood chipper is used to process the tree limbs to a particle size of 2.5 cm in diameter. Maintenance costs for the chipper are under $3,000 U.S. per year and one person operates the chipper for about 25 hrs/week. The yard waste for the operation is obtained through a curbside collection program and drop-off.

Biodegradable paper bags are used for storage and residents may place garden vegetation, leaves, grass and branches within. A 'Brown Bear' auger mixer is used to combine the yard waste, sludge and sawdust for composting. The entire composting takes between 90 and 120 days. Finished material is passed through a one-quarter inch Powerscreen prior to being given away to residents and commercial users. Pilot windrows composting only yard waste are being tested as a possible substitute to the sawdust.

Northwest Cascade in Puyallup, WA - composts yard waste with sludge and septage and adds nitrogen and nutrients missing in the sawdust. Equipment used to produce a high quality product includes a Fuel Harvester Tub Grinder and Screen Plant which produces fines about 2.5-3.8 cm which are composted and overs (oversized organic material) which are reprocessed through the tub grinder with smaller hammers and a 2.5-3.8 cm screen. The process is said to be "...more costly but produces a more thoroughly composted and more consistent end product" (Goldstein 1991).

Dupage, Illinois - uses Brown Bear brand machine to mix the feedstocks (3 parts yard waste to one part digested sludge). The total process takes 60 days. Finished material is processed through a 1/4 inch Powerscreen and the overs are fed back into the composting system and eventually get broken down. Compost is sold for $4 U.S. per cubic yard to nurseries, landscapers and sod farmers. This operation did experience odour and compaction problems as a result of composting leaves and grass with sludge because there were no wood chips to provide aeration.

Similar to sewage sludge, septage from rural areas has been treated through composting. A septage dewatering, treatment and composting plant is operational in the rural community of Thompson, New York. The septage is gravity fed through a sludge grinding unit, conditioned with polyelectrolyte polymer, and then pumped to the dewatering unit where much of the suspended solids and biochemical oxygen demand (BOD) are removed. It is then discharged to a storage tank where it is aerated for three to four days prior to discharge. Wood shavings are added to increase the solids content and porosity of the mix and mixture is then composted via the aerated static pile method. Septage is composted for a minimum of 21 days and then cured for an additional 30 days prior to product usage. Temperatures greater than 55 ^{0}C for at least three days are maintained to ensure the destruction of pathogens.

The biggest concern of the project was said to be "...the capability of the dewatering unit to produce a dry enough cake so that the composting portion of the process would be economical" (Williams et al., 1991). According to the author, dewatering of domestic septage with low levels of grease utilizing the Somat Screw Press is an appropriate technology for small scale septage composting facilities. The costs of dewatering and composting were $54.96 US/1,000 gallons of treated septage; capital costs were $117,941 US. If such a facility was using yard wastes as a bulking agent and if compost were sold to users, the costs of treating the septage would be reduced significantly from the $55 US per 1,000 gallons.

Barriers to Co-Composting with Sludge and Septage:

The release of heavy metals and other contaminants into the municipal sewer system is a major concern for co-composting with sludge because of the marketability of the end product. In Florida, using sludge to accelerate yard waste composting is discouraged by the state's compost rule requiring adherence to sludge composting rules even if only catalytic amounts are added to yard waste (Smith, 1990). One vendor of MSW composting systems proposes that sludge and septage can be composted with shredded wood in an in-vessel system, although it should not be added to the rest of the compost of organic MSW because of possible contamination by heavy metals. Most sewerage systems receive, not only human wastes, but commercial and industrial wastes which may be high in heavy metals and other potential contaminants. Household hazardous wastes entering sewerage systems and septic tanks are another source of concern with regard to potential compost quality. In Europe, the content of heavy metals and toxic organics in sludge is great enough to sharply restrict usage of the co-compost product. Similarly, other jurisdictions have defined the metal limits low enough in their compost regulations that the use of sludge would not be pursued as an option unless the level of contamination was expected to be non-existent or very low. B.C.'s compost regulations, which apply to MSW and sludge composting, are stringent with regard to allowable metal limits (see Table 6), but whether or not sludge should be used in composting processes will have to be evaluated on a case-by-case basis, dependent upon the amount of toxins in the sludge discharged from communities and industry treatment plants and their susceptibility to be adequately decomposed.

Table 6

B.C. Heavy Metal Concentration Codes

Codes:	1	2	3	4
Arsenic	<13	>13-30	>30-50	>50
Cadmium	<2.6	>2.6-5	>5-20	>20
Chromium	<210	>210-250	>250-800	>800
Cobalt	<26	>26-50	>50-300	>300
Copper	<100	<100	>100-500	>500
Lead	<150	>150-500	>500-1000	>1000
Mercury	<0.8	>0.8-2	> 2-10	>10
Molybdenum	<5	>5-10	> 10-40	>40
Nickel	<50	>50-100	>100-500	>500
Selenium	<2	>2-3	> 3-10	>10
Zinc	<315	>315-500	> 500-1500	>1500

Source: B.C. Ministry of Environment. July 2, 1990. Draft Regulation for the Production and use of Compost from Municipal Solid Waste for British Columbia.

6.2 Composting Diapers:

In response to the issue of landfilling disposable diapers, which are estimated to make up approximately 2% of the residential waste stream, industry representatives are involved in discussions with Canadian municipalities to explore ways in which diapers could be included in modern, large-scale composting programs. The Recomp MSW composting facility in St. Cloud, Minnesota, was engaged in a pilot project funded by Proctor and Gamble to compost disposable diapers in an in-vessel system. The diaper waste stream was increased to five times the normal amount and, according to Recomp, there was no observable change in compost quality. The diapers are said to be almost fully compostable, except for the polyethylene liner, which is less than 10% of a diaper's bulk. The end compost product at Recomp goes through a screening process where the plastic liners are removed prior to curing. According to one vendor of composting systems, the contents of diapers do not present a problem in the food waste stream due to the pathogen kill temperature which is achieved in-vessel. However, residue from the materials used to manufacture the diapers may result in a lower quality compost which may be of less interest to end users. "Diapers ...present a mixture of organic material which is compostable and inorganic material, such as plastics and absorbent material, which will not decompose but remain as visible or invisible contamination of the finished compost" (Airite Ltd., 1990). This vendor suggests that diapers could be included with sludge for composting, rather than with other MSW, because the incremental contamination from diaper material will not significantly increase marketing concerns for sludge compost.

With regard to diaper composting in Canada there are some outstanding issues to be addressed. According to John Hansen of the Recycling Council of Ontario (RCO): "If we are striving to make large-scale composting more viable, it is crucial that high quality standards be achieved. Frankly, I'm sceptical that diapers can do anything but detract from this" (Anon., 1991 a). There is also the issue of pathogens present prior to composting as workers will have to handle and sort soiled diapers. The removal of the plastic liner requires shredding and screening, although Proctor and Gamble is trying to develop a more compostable backsheet to replace the plastic liner. Most importantly, the issue of waste reduction through reuse has to be addressed before composting is considered for disposable diapers because "...if a nationwide (U.S.) diaper-pickup system were in place, it would take 44 Recomp plants composting nothing but diapers 365 days a year to turn the nation's stream of disposable diapers into compost" (Woutat, 1989).

7.0 MSW CENTRAL COMPOSTING INITIATIVES

7.1 Powell River Pilot Project:

The Corporation of the District of Powell River, B.C. and a company called Airite Environmental Industries implemented a pilot project from July 1989 to February 1990 to test the collection and composting of food and yard waste from approximately 300 households as well as a number of restaurants and institutional kitchens (see also section 5.1.2). The objectives of the Pilot Project were to demonstrate:

1) the in-vessel composting technology
2) that source separation of household organic waste will produce a clean, high quality compost
3) that there is a viable market for this compost
4) how to achieve high level community participation
5) that an effective program for providing this type of waste management approach is possible (including the provision of curbside collection, and a public education program)

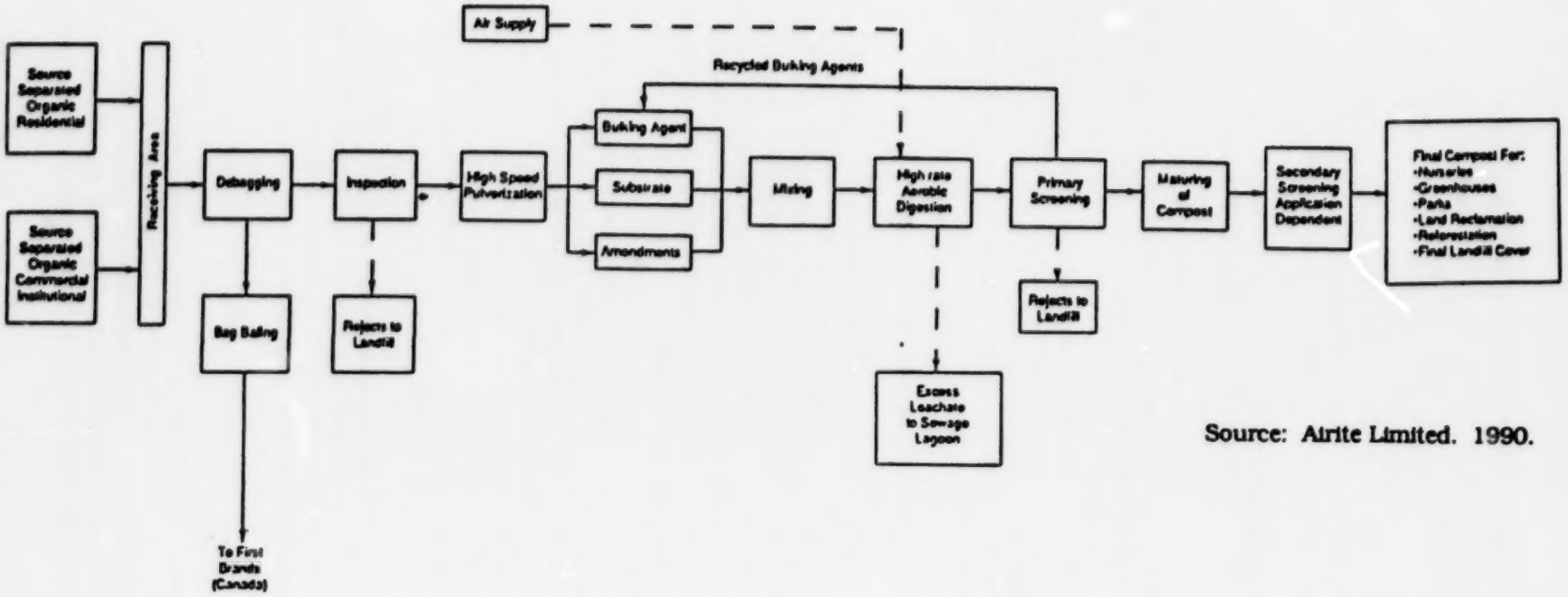
The operation involved recording information such as weight and volume of the bags of organics being collected from the curbside. The contents were debagged at the composting facility and put through a hammer mill for particle size reduction. Once mixed thoroughly with a bulking agent, different types of wood chips were tested and the material was loaded into the front end of a digester via a conveyor belt. Mature compost was removed from the digester and classified via a screen to achieve the desired particle size. Overs such as undigested bulking agent were recycled back into the mixing stage of the process. After the primary screening, the compost was cured and screened a second time as required by the end application (see Figure 2).

Feedstocks included restaurant food waste, residential food waste, yard waste and low grade paper, all of which were effectively composted by the in-vessel digester which aerated the mass by a series of fans. Air input was balanced to maintain oxygen content between 15-20%, to maintain ideal temperatures for composting, and to ensure pathogen kill (Airite Ltd., 1990). The control of odour is a major consideration in composting operations, especially with highly putrescible materials such as kitchen wastes. Although there were some problems with odour in the waste sorting and debagging once the material passed through the hammer mill, odour ceased to be noticeable. According to Airite, "the maintenance of aerobic conditions in the digester prevented the production of foul smelling gases which are typical products of anaerobic fermentation" (Airite Ltd., 1990).

A market study of potential compost users including local nurseries, landscapers and silviculturists was undertaken in order to determine the value of various compost grades. It was found by the survey that the three grades of the compost as produced by different sized screens could replace existing soil amendments and the market price of the compost approximated in the range of $5-$25/cubic yard. According to samples taken, the compost produced from the source-separated organics was low in heavy metals, all metals except copper met the B.C. Class 1 compost requirements -copper fell into class two- and the compost material had a pH suitable for horticultural and agricultural uses (pH=7.5). Requirements for pathogen kill were met by the in-vessel process as temperatures of greater than 60 ^{0}C were maintained in excess of three days.

According to a survey distributed to all participants at the end of the pilot project, a large majority of respondents (94%) said they would support a full scale composting program in Powell River. The Corporation of the District of Powell River supports the integration of some type of full-scale composting into its Regional District Waste Management Plan in the near future (Greenwood, 1991).

Figure 2
Powell River Pilot Compost Facility Layout



Source: Airite Limited. 1990.

7.2 Victoria CRD Composting Strategy:

The Capital Regional District (CRD) covers an area of 1000 sq. miles (2590 km^2), including 10 municipalities and 4 electoral areas. The total population of the CRD, including the Gulf Islands, is 285,000. To meet waste reduction objectives set out by the Province of British Columbia (see *Program For Participation*), the CRD is developing a three-point composting strategy for the organic fraction of the waste stream. The CRD composting strategy encompasses three levels of initiatives: backyard (on-site) composting, municipal yard waste transfer program which will be refined in consultation with each municipality, and a regional facility at the Hartland Landfill. In meetings between the CRD staff and municipal engineers in February 1990, it was decided that MSW composting in the CRD should be approached by source-separating organics in order to produce a high quality product. All three levels of the CRD's proposed composting strategy employ sorting of organics prior to the composting stage and prior to collection or storage.

Backyard composting:

The CRD is currently encouraging backyard composting through a number of education programs. A demonstration compost site displaying various composters is planned as well as a demonstration garden to provide hands-on experience in composting to CRD residents. Although a garden site has not yet been procured, the City of Victoria is an area targeted within the CRD because of its high population density, allowing good public exposure. The CRD, the Sierra Club and the City of Victoria will be working together to access funding, and prepare the demonstration site for public use by the spring of 1992. Once one site is in operation, the enthusiasm may spread to other municipalities.

Another CRD component of the program is the provision of a "backyard composter educator" who will travel to various centres to provide information about backyard composting. The educator will be equipped with demonstration compost bins, "how-to-BYC" pamphlets and information on how to prepare organics for backyard composters. This program will run every weekend from September 1991 to November 1991 (six to eight weekends). Demonstration compost bins will also be set up at Oak Bay's municipal yard parking lot, and an information kiosk will be set up to make printed information available to residents interested in composting food and yard wastes.

Municipal Transfer Program:

There are a number of options with regard to the municipal yard waste transfer program. The municipal program may involve initiation of transfer stations at each of the ten (10) municipalities and four (4) electorial areas located within the CRD for drop-off of yard and garden debris. Centre feedstocks will consist mainly of heavy brush, leaves and grass clippings. The particle size of bulky yard wastes may be reduced at each municipal transfer station by chippers, thus facilitating more economic transfer to the Regional Composting Facility. Wastes may also be transported to the facility at Hartland without undergoing any pre-processing. Alternatively, municipalities within the CRD may set up their own composting operations. At least one municipality in the CRD, Oak Bay, is composting its municipal yard waste (see section 7.3), and other jurisdictions have expressed interest in this level of composting, unfortunately, land and technical staff may not be available to some municipalities for this type of operation.

Regional Composting at Hartland Landfill:

The pre-design process with which the CRD/CH2M Hill Planning Team has been involved in setting up the Regional Composting Facility is complicated by options regarding feedstocks, phasing and ownership/operating structure. The following section is intended to give a description and analysis of this procurement process to date.

Regional Facility Procurement:

The CRD issued a Request For Proposal (RFP) for the design, construction, and operation of the Regional Composting Facility at Hartland in July 1990 in order to:

1) assist the CRD in implementing its three point composting strategy
2) evaluate industry submissions, including capital and operating costs
3) request capital funding including facility and associated transfer stations
4) select a group of qualified vendors to initiate negotiations or solicit detailed cost bids

The Request For Proposals documents, prepared by CH2M Hill, outlined the general objectives and requirements for the proposed composting facility. Vendors were required to complete a "Schedule of General and Technical Information and Costs" . The vendors were requested to outline how they intended to process yard waste, kitchen wastes and sewage sludge. At the time the initial RFP was issued, the goal of the CRD was to "establish a Central Composting Facility ...to receive kitchen waste from the commercial and institutional sectors and yard waste from municipalities". The CRD's decision to process sewage sludge at the composting facility was to be made "...based on information provided by the Proposers in this proposal and on other studies that may be completed by the CRD in the future". No structured information regarding facility phasing was provided at this time other than the recognition that the quantity of feedstocks would increase during the life of the project. Various requirements were laid out in the RFP document regarding the operating structure.

With regard to ownership, it was not determined at the project outset if the Central Composting Facility would be owned by the CRD or by the vendor. In the CRD's view, one advantage of vendor ownership of the Central Composting Facility is the transfer of risk and administration to the private sector. Disadvantages may include higher debt servicing, and longer timeframe to procure the site and obtain approved zoning ordinances. However, the CRD ownership would allow for exemption of property taxes since the land is owned by the regional district and the provides a government service. Conversely, CRD ownership includes additional insurance risks and costs and additional administration and staff supervision.

Fourteen responses to the RFP were received and evaluated by CH2M Hill and CRD technical staff. Based on this evaluation, three vendors (Daneco Inc., Recomp Inc., and Wheelabrator Technologies Inc.) were shortlisted for further assessment. A more detailed set of requirements and design criteria were distributed to three shortlisted vendors in March of 1991. Included in that Addendum was the CRD's strategy to establish the Central Composting Facility using a phased approach. In Phase I, the facility will accept yard waste, " ...the quality and consistency of which can be closely regulated, which will produce a marketable end product, and which represents the lowest cost per tonne to compost" (CRD, 1991). The subsequent Phases II and III will involve the addition of limited quantities of other feedstocks and evaluation of the effects on compost quality, process, economics etc. will be assessed. Phase IV will involve the processing of source-separated organics in a facility designed for this purpose. Finally, Phase V will entail a review of previous operations, leading to adjustments in feedstocks etc., prior to continued operation of the facility.

The phased approach described above could be implemented using the following: (1) Build one high technology, in-vessel, indoor facility, which could accept yard waste, food waste, sludge, septage and diapers; (2) Build a smaller, low technology, open air windrow facility for yard waste only and using an associated phased approach, evaluate, and implement if appropriate, through private or public initiative, a thermophilic digestion approach for food waste, sludge and septage. Assessment of promising new technologies for the separate processing of disposable diapers would follow.

With regard to feedstocks, the CRD/CH2M Hill planning team considered the second option more desirable and compatible with the phased approach than the former for a number of reasons. A major advantage of the windrow/thermophilic digestion approach is that a precise determination of feedstock quantities is not required prior to the facility implementation. Conversely, the type and volume of organics to be composted in an in-vessel composting plant would have to be known before such a facility was built. Factors such as burning bans, method and frequency of collection, the success of the backyard composting plan, and the involvement of the municipalities

in municipal and regional composting programs would make this determination difficult. The thermophilic digestion system is also thought to be more compatible with the phased approach than the in-vessel facility, while still offering the prospect of less risk, lower cost and greater flexibility of operation.

The CRD also preferred the low-tech windrow option because some communities felt that smaller-scale, sub-regional composting facilities may be preferable to one large composting facility at Hartland. The building of a high-tech in-vessel facility for all feedstocks would essentially eliminate the sub-regional option in the future. Secondly, in-vessel plants are considered by some to be "inappropriate technology" since they are high consumers of energy. Although windrow composting facilities also have energy requirements for operating machinery such as grinders, screeners, compost turners, etc., the power required is minimal in comparison to in-vessel systems.

The proposed Regional Composting Facility will be implemented using a phased, modular approach, as follows:

Phase I Construction of an open air, windrow facility at Hartland landfill with a capacity of about 10,000 tons per year for yard waste only, with facility operation and compost marketing to be contracted out.

Phase II When required, construction of an expansion to the Hartland composting facility, or a facility at another suitable location, or, if multiple materials are to be composted (such as food waste, sludge, septage, or diapers) construction of an in-vessel, indoor facility to the required size.

Phase III When required, construction of a further expansion to the central composting facility at Hartland, or a facility at another suitable location.

7.3 Oak Bay Municipality Yard Waste Composting:

The municipality of Oak Bay within the Capital Regional District is currently operating a successful composting facility for yard wastes. A drop-off system at the municipal yard collects 3,000 to 4,000 tonnes/yr of brush, lawn clippings and garden debris which are transported to a central site for preparation and composting. Oak Bay has no collection of yard waste from the home with the exception of one pick up in spring and leaf collection in the fall because it is not considered to be cost-effective to do so. The drop-off depot for yard waste is a low-cost collection method, however, there are some problems with people mixing in contaminants with yard waste despite visible signs discouraging this.

The actual composting operation involves the grinding, windrowing, turning and screening of yard waste. A front-end loader with a "four-in-one" bucket is used to load the incoming yard waste into the tub grinder. The shredded material is watered as it goes over the conveyor to form an elongated pile. The windrows are turned once a month with an excavator to provide aeration and bring the temperatures up. Two weeks after grinding, the material in the windrows usually reaches a temperature of about 60 ^{0}C and will rise almost ten degrees once turned in two weeks time. After about one year, when the material cools to 40 ^{0}C or lower, the screening process begins. Oak Bay utilizes a flat-bed vibrating screen to sort the fines (<1/2") from the larger material. The screened compost is ready for use and the oversize materials (overs), usually about 25% of the material, are fed back into a windrow for further composting. The municipality has received another screen (7/8" by 3") to produce a second, coarser compost for uses that do not require the finer textured product. Overs from the screening process are not fed back into the grinder for particle size reduction because the site is unpaved and as a result a number of rocks are picked up with the organic materials. Screened materials became too wet during the winter, so in the future, Oak Bay plans to cover the piles with tarps to allow for further curing.

Because of the homogeneity of the material, leaf composting requires less management than composting other yard wastes. Leaves, collected separately, are ground when they are fresh to avoid having them stick together and are then placed in 'leaf only' windrows. However, leaves from the fall of '90 were not put through the tub grinder. The product quality from the shredded leaves is predicted to be much higher than that from the leaves that were not pre-processed. Once windrowed, the piles are turned once a month for approximately 1.5 years, the time required for the leaves to decompose. No watering is required because the leaves retain moisture at about 40-60%. Once the finished compost is screened, it is ready for use as a soil amendment.

With regard to costs, the grinding of materials is the most expensive step of Oak Bay's yard waste composting operation, costing about $90/hr to operate the tubgrinder. To resurface the hammers in the tub grinder costs about $150-160 for each day of use. After 4 days the entire set of 64 hammers must be either resurfaced or replaced, the latter of which costs about $600 if fabricated at the public works yard, or $1,300 if purchased from a supplier. The screening procedure costs approximately $50/hr, with an initial purchase price of $50,000. However, there are benefits to be gained. The compost is a quality product and is being sold at $14 a yard. Some of the finished compost was mixed with sand, but no economic advantage was realized so the practice has been discontinued. This year all of the mature compost has been sold to individuals and private contractors, or utilized for landscaping by the municipality of Oak Bay. Oak Bay maintains that the yard waste composting operation is a profitable venture, even without taking into account the sales of the product. Their composting process is less than one-third the cost of landfilling yard waste:

landfilling = $55/tonne tipping fee + $10/tonne transportation
vs.
composting = $17/tonne net costs).

7.4 Vancouver Leaf Composting Project

The City of Vancouver is involved in a leaf collection and composting program which began with the composting of leaves from City streets. In 1989, 3,000 tonnes of leaves were collected during the street collection program and all of the leaves were composted by the winter of 1990 (Henderson, 1991). All of the 2,000 m^3 of compost produced has been distributed to end users, including the Parks Board, Engineering Department, the G.V.R.D., and Compost Demonstration Garden. In the fall of 1990, city crews also collected leaves set out by residents in clear plastic bags for transport to the composting site. Leaves could also be dropped off free of charge at both the Vancouver South Transfer Station and the Vancouver Landfill site in Delta (City of Vancouver Engineering Dept., 1991). About 4,000 tonnes of leaves were collected from the existing street leaf collection program and an additional 1,000 tonnes were collected from the curbside pickup and residential drop-off. The composting process itself is a low-tech windrow system. The leaves are placed in windrows and turned once a month with a front-end loader for approximately eight months. The material is shredded after the composting process to ensure a quality product. Chemically, the compost produced in 1990 had "no contaminants exceeding regulatory levels for unlimited use in any jurisdiction in North America" (City of Vancouver Engineering, 1991) and, although the compost was not sold to end users, its value was estimated at $10 to $15 per m^3.

The operation has been deemed successful and has been approved by City Council to continue collection and composting of leaves. Screening of the shredded compost will be carried out with a rented double deck vibrating screen in order to increase the value of the compost by removing glass, plastic, and wood waste. The City has switched to kraft paper bags from plastic for curbside collection of leaves to speed up the collection process as this way no debagging is required and the quality of the end product is increased by avoiding plastic contamination. Paper bags are readily compostable with enough moisture. The incentive for the purchase of the bags is the reduction in garbage pickup from five cans to three and, therefore, less opportunity to throw leaves in with the regular trash. The composting program will eventually be expanded to include mixed yard waste collection and composting (Henderson, 1991).

7.5 Cedar Grove Compost Co., Maple Valley, Washington:

Yard waste from the City of Seattle, King County and areas surrounding Snohomish County is collected and brought to a central composting facility in Maple Valley, Washington. The facility commenced operation in the spring of 1989 and is run by New Waste Industries, Inc., a private company involved in waste management. According to Suzanne Leger, the Marketing and Sales representative, their yard waste composting operation is probably the second largest in the country. Approximately 50,000 tons of yard waste, including leaves, grass, brush and pruning materials, were pre-processed and composted in 1989 using the windrow method. A disc screen is utilized to separate the grass and fines from the larger fraction, the latter of which is put through a high speed hammermill grinder for particle size reduction. All of the material is then combined and windrowed for five to six weeks. The mixing ratio of materials in the windrows is 1:3/4 (grass to leaves and woody material) (Glenn, 1990 b). Twice weekly, a Scarab windrow turner further shreds, separates bags, aerates and fluffs the material to make a uniform consistency throughout the piles. After about six weeks the material is moved to curing piles for up to 6 months. The products include a fine grade compost (1/2" particle size), a topsoil mix (50/50 fine grade compost and topsoil mix) and a mulch (3/4 - 1 1/2") for landscaping and municipal uses.

According to a survey of compost facilities in Biocycle, the Cedar Grove Compost Facility has a capital cost of 2 million dollars U.S. and employs 12 to 15 people on a full time basis. The site is paved to help control leachate/runoff and to provide all-weather access. Leachate is channelled to a catch basin, then to an aeration pond, and finally to a sedimentation pond prior to discharge (Glenn, 1990 a). Some of the other sites identified in the survey controlled leachate by: 1) percolation through the areas' soil; 2) recirculation into the windrows and; 3) filtering through a grass strip, into a discharge pipe, and finally into a 457 metre grassy ditch prior to discharge into a local stream. The actual numbers associated with the quality of the treated leachate were not included in the article. However, it was mentioned that the water tests conducted usually looked at organic, pesticide and heavy metal concentrations.

Contact person:	Suzanne Leger, Marketing & Sales Rep., Cedar Grove Compost Co. 54 South Dawson Street Seattle, Washington 98134 Phone: (206) 763-2700; fax (206) 764-1234
Compost site Address:	17925 Cedar Grove Road Maple Valley, Washington 98038

7.6 Fish waste composting:

With rising landfill costs, concerns about water quality and the demand for high quality soil amendments, the composting of agricultural/ commercial wastes is on the rise. The traditional method of landfilling fish carcasses is expensive and wasteful of a valuable resource because "the utilization of compost for agricultural purposes, while not a large market at this time, would enhance sustainable agricultural production" (Holbek, 1990). The amount of fish waste generated in B.C. alone is approximately 110,000 tonnes. According to the Ministry of Agriculture and Fisheries, some fish waste composting is being carried out in B.C.'s Sunshine Coast area. As well, UBC Research Farms in Oyster River on Vancouver Island have proposed to build and operate a fish waste composting plant, pending rezoning of the site. As another example, the Land Resource Centre in Ottawa has recently developed a passively aerated windrow composting method to safely dispose of 200,000 tonnes of fish waste produced yearly in Atlantic Canada.

In the Maritimes and the Eastern United States, the composting of fish waste from both commercial and sport fisheries is getting considerable attention. The Sea Grant Extension Service in Michigan has two pilot projects underway to compost fish waste - one in Harrisville that serves salmon sport fishing and the other in Rogers City for a commercial whitefish industry (Logsdon, 1991). Both projects utilized the static pile method to compost the mixture of fish waste and bulking agent (1:4 fish waste to chipped brush and wood chips). Approximately 10-20 cm of bulking agent was used to cover the windrows for insulation. The windrows were 1.8 to 2.4 metres wide and

approximately 1.2 metres high and were left for two months to compost. Temperatures remained at 65.5 ^{0}C for four to six weeks and when the windrows were torn apart, after six to eight weeks, the fish carcasses were said to have disappeared. After the two month windrow period the compost was moved to large conical piles (4.6 m in diameter and 6 m high) for final processing of the brush and wood chips. Odour was not a problem throughout the composting process. The brush chips take 18 months to decompose and the wood chips take 2 to 2.5 years to decompose. However, the process would be speeded up with a turning program. When finished, the compost would be run through a hammermill, or similar grinder, prior to marketing.

Although the above pilot projects did not appear to experience anaerobic conditions, static pile systems often become anaerobic. According to Neils Holbek of UBC Research Farms in Campbell River, B.C., the static pile method is the least desirable for fish waste composting, especially in areas where extended high periods of precipitation are anticipated to occur (Holbek, 1990). The best suited systems appear to be the agitated (turned) windrow or agitated bin systems. The latter system employs a turning machine travelling on tracks above a bed with or without aeration from below.

7.7 Fraser Valley Industrial Composting Plant:

Envirowaste Industries Inc. plans to develop a $3.5 million industrial composting plant, located just outside Matsqui, British Columbia. The facility, which will handle agricultural waste, animal manures, fruit, vegetable, food processing wastes etc., and is scheduled for completion later in 1991 and is said to be "Canada's first industrial composting plant" (Envirowaste Industries Inc., 1991).

7.8 Comox/Strathcona Regional District

Large-Scale Composting Operations:

• Regional District - composting of sewage sludge derived from secondary activated sludge treatment for past seven years. Using the aerated static pile method, sludge is mixed with wood chips as a bulking agent, composted for about 21-28 days and then cured for three weeks. Screening is carried out to recover the bulking agent for re-use in the next batch. From 600-800 m^3 of finished compost has been produced each year and sold for about $20 a pickup load. The Parks Department has been a major user of the compost for landscaping. Testing and analysis of the compost has shown the product to be within the limits in B.C. Environment's proposed sludge regulations with regard to metals and pathogens. The Regional District has been using compost on gardens and has been sending the crops out for analysis. No significant uptake of heavy metals was noted during the testing.

•Biotech Resources - involved in septage composting. Septage is dewatered, mixed with sawdust and wood chips, and composted using the turned windrow method. The resulting compost is sold and used on market gardens.

•Proposed Fish Waste Composting Plant - Oyster River (see section 7.6)

Small-Scale Composting Operations:

•At the Comox landfill, leaves and grass clippings can be dropped off free of charge for composting by the Regional District. The material is windrowed and turned with a front-end loader once a week. The operation commenced in the spring of 1991 so there is not yet any finished compost ready for distribution. It is anticipated that the compost will most likely be given away to users because, in one sense, they have already paid for it through taxes and by supplying the raw materials. Also proposed is the development of a separate area at the landfill to chip larger woody material such as pallets and tree prunings for use as a bulking agent in local composting operations.
Contact: Graeme Faris, Director of Environmental Services. Comox-Strathcona Regional District. Courtney, B.C., P.O. Box 3370. Phone # (604) 334-4452.

8.0 CLIMATIC CONSIDERATIONS

In areas with excess precipitation, such as the coastal regions of B.C., anaerobic conditions can occur in piles of uncovered organic material. As well, unless proper insulation is supplied, prolonged periods of freezing temperatures can inhibit the composting process. In summer, hot weather can dry out the composting material, making it less amenable to biological decomposition. These factors should be taken into consideration in any composting operation, from a single-bin backyard composter to a large-scale municipal composting operation. Most climatic barriers to effective composting can, however, be overcome by covering or insulating the active composting area and the curing area. Completely enclosed composting facilities, such as in-vessel systems, are equipped with temperature control and are generally not subject to climatic variations.

Composting using the turned windrow and static aerated pile methods is best undertaken on a concrete or asphalt slab and under a roof in areas with high rainfall. With regard to the static aerated pile method, "failure to reach temperatures required for pathogen kill has been experienced when the piles were built unprotected during the winter months in coastal B.C.. Furthermore, there is concern about the distribution of temperature within the pile and the potential for some portions of the pile failing to achieve the required temperature/time requirement mandated for pathogen kill" (Holbek, 1990). As well, the turned windrow method is often difficult and problematic in the rainy season due to high runoff and poor ground conditions. High rainfall can also cause material in uncovered windrows to clump, making it difficult to screen in the final processing. For example, at the composting plant in Fillmore County, Minnesota, curing the compost outside was subject to problems resulting from too much rain. "The compost has not adequately dried for screening ...a compost curing building to shelter the compost from precipitation is being considered" (Biocycle, 1991).

Uncovered piles of compost are also subject to nutrient leaching when heavy rains persist. A more economically feasible method than roofing the composting area to mitigate such problems, is to cover individual windrows with plastic covers to shed the rain. However, the site may still experience considerable problems with drainage if not designed and managed to control runoff. Covering the windrows with plastic or some other material such as burlap also helps to retain moisture in otherwise exposed compost piles during hot weather.

In periods of prolonged freezing temperatures, the composting process can still be carried out. In a test of a 'Soil Saver' backyard composter over a one year period, it was found that worm activity and moisture was still present in the centre of the pile, although the compost was frozen for about six inches from the sides (Elcock, 1991). On a larger scale, Minnesota companies have been engaged in successful composting outdoors despite cold winter temperatures. As well, Heritage Mushrooms in Alberta can bring temperatures of windrowed material up to 82^0 C (180^0 F), even in prevailing winter temperatures of -40^0 C. The pile is said to freeze on the outside, but microbial activity on the inside of the pile continues. Steam injection is sometimes performed to initiate the rise in pile temperature (Hazelwood, 1991).

9.0 PRODUCT UTILIZATION AND MARKETS

Compost produced in backyard composters at residential dwelling sites or at demonstration gardens is generally a very high quality soil amendment that can be used in a number of ways. Compost can be mixed with potting soil and used for houseplants and planter boxes, sprinkled on the lawn as a conditioner, or used directly in the garden as a mulch or else dug into the soil (Levenston, 1991). While implementing a backyard composting program, municipalities should educate residents as to the benefits of compost for the creation of healthy soil which will enable them to reduce their reliance on chemical fertilizers and soil amendments in their yards.

With larger scale composting operations markets should be developed prior to the facility's implementation. Marketing plays an important role in the ultimate effectiveness of any program to compost wastes. A major step in developing markets for compost is to acquaint the potential users and regulatory agencies with the product's viability as a soil conditioner and resource (Williams and Epstein, 1991). The development of a pilot study is often the most appropriate way to demonstrate the quality of the compost and its potential uses. Users of compost may range from public agencies, who may require large volumes of material for land reclamation and other projects, to nurseries, who

prefer a more refined product (see Table 7). Providing analytical data pertaining to compost quality is very important, especially with regard to nutrients, pathogens, organics, metals and foreign matter. This is necessary because, in British Columbia as in many other jurisdictions around the world, there are either regulations being developed or already in place governing the production and use of compost products. Revenue from the sale of high quality compost products serves to offset the cost of processing and, therefore, will provide an incentive to industry and governments to implement programs that guarantee a product that is acceptable for most uses within applicable regulations.

Table 7

Categories of Compost Users

Users	Preferences
Growers: Golf Courses, greenhouses, home gardeners, landscape contractors, nurseries, sod and turfgrass growers	***Growers*** prefer a refined compost product to meet specific chemical and physical criteria; for potential use as a field or potting soil amendment.
Processors: Fertilizer contractors, fertilizer manuf./supply, topsoil firms, Some sand and gravel businesses	***Processors*** will refine compost product to their chemical and physical specs. will require strict quality control by the compost producer.
Wholesalers and Retailers: Garden centres, greenhouse equip./supply businesses, lawn and garden equip./supply firms, nursery equip./supply businesses	***Wholesale/Retail*** markets generally prefer a bagged product for resale.
Public Agencies: Land reclamation, landfill cover, Parks and Recreation depts., Highway & Transportation depts.	***Public Agencies*** represent operations that use compost in volumes, on large acreages. These are frequently in-house types of use.
Service Organizations: Landscape planning & design firms, provincial & regional transportation depts.	***Service organizations*** are in a position to specify the use of compost on building and landscaping construction and maintenance projects.

Source: Williams & Epstein. April 1991. Waste Age. Volume 22, No. 4.

Any revenues obtained from selling the compost product, however, are often secondary in importance to the objective of volume reduction of municipal solid waste and resource conservation. In places such as B.C., where approximately 60% of our landfills will be at capacity by the year 2000, volume reduction alone is enough reason to implement a compost program.

The composting process itself results in a significant reduction in volume of organic waste and, even if the finished product were simply disposed of in a landfill, some space would be conserved. The demand for compost made from MSW for restoring the structure of farm soils is predicted to rise (Anon., 1991) and, therefore, higher end uses than landfilling should be pursued for such a valuable product. Having to use compost as landfill cover due to high levels of metal contaminants or foreign matter is essentially a waste of an important resource.

The value of any program to compost wastes is greatly increased when an end-use for the product is secured, "the quantities of waste requiring landfill are reduced further, and a beneficial use for the product is found" (Ontario MOE, 1990). The closed loop approach to waste management, where a product is not only collected and processed but procured by end-users, is essential for creating a more sustainable society by conserving natural resources instead of throwing them away.

10.0 CONCLUSIONS

Composting programs can be implemented on a number of scales. On-site composting can be encouraged by municipalities through educational tools such as brochures, compost/recycling "hotlines", videos and demonstrations. Subsidizing the purchase and distribution of composting bins is another potential option for municipalities seeking to promote this scale of composting. Besides traditional backyard compost bins, in-house systems such as vermicomposting can also be effective in processing organic kitchen wastes. Public resistance, however, will have to be overcome in order to implement on-site composting on a wide scale.

One important way to educate the public with regard to composting is to encourage the establishment of demonstration compost/garden sites in neighbourhoods. Such neighbourhood composting sites can use local resources, such as horse manure and straw from riding stables and vegetable and fruit scraps from local supermarkets in the composters, to supplement organic wastes produced on-site. As well as demonstrating the effectiveness of various types of compost bins, neighbourhood compost sites can be integrated with demonstration gardens or allotment gardens to show the potential end uses of the compost product. The goal common to all existing and planned demonstration gardens is, by providing technical advice and a source of inspiration, to encourage visitors to set up and maintain their own system for composting.

Backyard composting and neighbourhood composting initiatives have a number of advantages over larger-scale facilities. Composting on-site offers residents the opportunity to take responsibility for their own actions as generators of waste instead of contributing to the "throwaway society" paradigm. This paradigm, or worldview, is one in which waste is generally not considered for its resource potential, but buried or burned.
The costs of implementing backyard/neighbourhood programs are low in comparison to central composting initiatives because there are virtually no collection costs, little equipment and power needed and minimal space requirements. Preliminary studies on backyard composting reveal that it has the potential to be a highly cost-effective waste diversion option (ESP Coalition, 1991). This level of composting also provides a high quality product that can be used for gardening and landscaping by the compost manager or resident.

Limitations of backyard and neighbourhood composting programs lie in their inability to accept certain types of organics such as meat, fish and dairy, their volume constraints, and public resistance. As well, many institutional, commercial and industrial (ICI) operations produce a significant volume of organic wastes that requires a higher level of management and infrastructure than single composting bins. Central composting systems for source-separated organics can be implemented in municipalities with significant organic waste streams, major markets with commercial-grade compost, and an established waste collection infrastructure. Yard and garden waste and kitchen waste can be collected by the municipality or its agent for drop-off to a centralized composting facility. Alternatively, a drop-off system for organic wastes can be established to provide feedstocks for the municipal/regional composting facility. Successful programs for composting yard waste, sludge, fish wastes and source-separated household organics have all been outlined in this report in order to demonstrate some of the options available to municipal governments and others for processing organic wastes into a useful humus product.

Some central composting systems include the manual and mechanical sorting of mixed MSW at the facility prior to, active composting. Such separation can be part of a "full stream" resource recovery facility (RRF) which serves a number of waste management options, including composting, recycling, and preparation of "refuse-derived" fuels. A higher percentage of each material is recovered in such systems that sort MSW after its collection. However, the compost product and the recyclables are often contaminated due to their commingled state prior to separation. Although this option may be attractive to municipalities because it does not require special collection considerations, it has not yet proven itself, especially in terms of the quality and marketability of the final compost product.

The designing of a municipal composting program involves a number of steps. An estimate of the sources, composition and volume of available compostable materials as well as a determination of end-use markets are among the initial steps. If backyard composting is selected as the major composting option for residential organic waste, end-use markets are already established. Central composting operations, however, must consider marketing prior to the system's implementation and the necessary processing requirements defined to match the end-use markets. Appropriate collection systems for central composting should also be designed keeping in mind the desired product quality. For example, wet/dry household collection systems will provide a cleaner organic feedstock than that from mixed MSW collection. Once the composting system is designed, a system for monitoring and testing should be established to ensure that the product meets applicable regulations. Backyard composting programs should be followed up periodically through surveys and other means to evaluate participation levels of householders and to estimate the volume of organic wastes being diverted from the landfill.

A combination of backyard and central composting programs can potentially divert a significant portion of the MSW stream from the landfill, while at the same time providing a valuable product in the form of humus. Furthermore, individuals and the ICI sector involved in separating organics and recyclables from the rest of the waste stream for composting will begin to take responsibility for the waste they produce. Composting therefore, can be valued in terms of revenue savings, its environmental and resource benefits, and for its potential effect on waste generator attitudes and behaviour. If municipalities are to achieve high waste diversion levels, the future implementation of composting programs is essential.

11.0 RECOMMENDATIONS

- With regard to on-site composting, it is recommended that residents in single and multi-family dwellings be encouraged to compost their yard and kitchen wastes at home since this is the most cost-effective and "environmentally friendly" method of reducing the organic fraction of waste going to the local landfill. Education programs and government financial credits towards composting bins are the main ways of promoting this scale of composting throughout the Province.

- The development of neighbourhood composting sites, in the form of demonstration compost gardens, is an important way for local governments, environmental organizations and individuals to work together towards a common goal of providing education to the public regarding composting. Such initiatives should be encouraged and implemented in as many B.C. cities and communities as possible.

- Composting systems at all levels currently encompass a wide variety of process technology which can be expected to develop and change rapidly as existing systems are refined and new ones developed. Further research in the area of composting technology is needed, especially with regard to developing the most cost-effective and efficient central composting systems for a variety of organic municipal feedstocks.

• Communication among all levels of government, industry, environmental organizations and other groups is essential to facilitate the spread of new information pertaining to composting methods, collection systems, markets and applicable regulations. This report identifies some of the local contacts involved in the composting field. It is recommended that some of these people and organizations be used as a source of information and expertise in the field.

• To successfully market compost, it is critical that the process produce a consistent, high-quality material in terms of pathogen kill, levels of potentially toxic materials and foreign matter. It is therefore recommended that central composting in the Province of B.C. be regulated to exercise careful control over the actual process and end-use of the product.

• The B.C. Environment hierarchy with regard to MSW management options should be followed in implementing composting systems. Composting systems should target organic materials that can be separated or kept separate from the bulk of MSW to facilitate their conversion into a high-grade product. Examples of such materials are yard wastes, food and food processing wastes, and sewage sludges. Other organic materials, such as food-contaminated paper, for which higher grade uses through recycling are not available, should also be considered for composting, provided that they do not jeopardize the quality of the end product. Some people believe that resources devoted to increasing paper recycling should focus on the recovery of these materials in preference to food-contaminated paper for composting.

Appendix A

Equipment Distributors

Equipment	Manufacturer	Purpose	Distributor/Contact
Tub grinder	Haybuster Mfg.,Inc., Jamestown, North Dakota	particle size reduction; grinding tree limbs & other yard waste	Gemaco Sales Ltd. 991 Ellis St., Kelowna, B.C. V1Y 1Z3 Phone:(604) 762-3939 Fax: (604) 762-5755
Tub Grinder	Saturn Manuf., Grand Prairie Texas	particle size reduction	Rollins Equipment (Headquarters) 415 East 5th Ave Vancouver, B.C. V5T 1H8 Phone:(604)874-6404 Fax:(604) 874-5534 (other offices in Victoria, Langley, & Duncan)
Stump waste Recycler	Recycling Systems, Inc. (RSI) Winn, Michigan	particle size reduction;capacity for large debris (8' infeed diameter)	EPS Recycling Box 4300 Aldergrove, B.C. V0X 1A0 Phone: (604)533-1234 Fax: (604) 530-3916
Small Industrial Chipper	RSI	particle size reduction	EPS Recycling
Auger System Grinder	Iggestund	particle size reduction	Iggestund Recycling P.O. Box 380 Nisswa, MN 56468 218-963-4343
Compost Turner	Wildcat Mfg. Co., Freeman, South Dakota	turn, aerate, blend windrows, pulverize	Gemaco Sales Ltd.
Windrow Composter	Scat Engineering Delhi, Iowa	aerates and reforms windrows	Rollins Equipment
Trommel Screening	Wildcat	screening/also incorporates conveyors	Gemaco Sales Ltd.
Integrated Composting Station	Royer Industries Inc., Kingston, Pennsylvania	particle size reduction; screening; conveyors; mixing etc...	Rollins Equipment
Self-propelled Sludge Mixer	SSI	mixes sludge w/amendments; produces windrows or static piles	Gemaco Sales

COMPOSTING EQUIPMENT AND SYSTEMS FOR SOLID WASTE AND SLUDGE

COMPOSTING SYSTEMS: SLUDGE, MSW, YARD WASTE

AD+SOIL
Walnut Road Business Park
210 Gale Lane
Kennett Square, PA 19348
215-444-5288

Agripost, Inc.
P.O. Box 2449
Pompano Beach, FL 33061
305-971-9167

Amerecycle
P.O. Box 338
Sumterville, FL 33585
904-568-1100

American Bio Tech, Inc.
P.O. Box 19769
Jacksonville, FL 32245
904-724-2424

American Recovery Corp.
2000 Pennsylvania Ave., N.W.
Suite 8350
Washington, D.C. 20006
202-457-6610

Ashbrook-Simon-Hartley
P.O. Box 16327
Houston, TX 77222
713-449-0322

Bedminster Bioconversion
52 Haddonfield-Berlin Road
Suite 1000
Cherry Hill, NJ 08034
609-795-5767

Bio Gro Systems
180 Admiral Cochrance Dr.
Suite 305
Annapolis, MD 21401
301-224-0152

Bird Compost Management
4140 Skyron Drive
Doylestown, PA 18901
215-348-9788

Buhler Inc.
P.O. Box 9497
Minneapolis, MN 55440
612-545-1401

California Co-Composting
Systems, Inc.
P.O. Box 10998
Marina del Rey, CA 90295
213-306-4195

Cobey Composting
4250 S.R. 309
Galion, OH 44833
419-468-2288

Compost Systems Co.
9403 Kenwood Road
Cincinnati, OH 45242
513-984-0625

Cooperative Waste Industries, Inc.
271 LaFond Avenue
St. Paul, MN 55103
612-488-9246

Daneco, Inc.
450 Park Avenue
Suite 2104
New York, NY 10022
212-582-8150

Ebara Environmental
P.O. Box 516
Greensburg, PA 15601
412-832-1200

Ecology Systems & Design
P.O. Box 1795
Murfreesboro, TN 37133
615-898-0074

Enviro-Gro Technologies
Caton Research Center
1540 Caton Center Dr.
Baltimore, MD 21227
301-536-9000

Environmental Recovery Systems, Inc.
1625 Broadway, #2600
Denver, CO 80202
303-623-1011

Fairfield Service Co.
240 Boone Avenue
Marion, OH 43302
614-387-3335

Farmer Automatic
P.O. Box 39
Register, GA 30452
912-681-2763

International Process Systems
Salmon Brook Corp. Park
655 Winding Brook Dr.
Glastonbury, CT 06033
203-657-3447

LH Resource Management
Walton, Ontario
Canada N0K 1Z0
519-887-9378

Naturizer Technologies
P.O. Box 755
Norman, OK 73070-0755
405-329-2725

Omni Technical Services
50 Chas. Lindberg Blvd.
Uniondale, NY 11553
516-222-0708

OTVD
135 E. 57th St.
23rd floor
New York, NY 10022
212-755-7600

Recomp, Inc.
1500 E.79th Street
Suite 102
Bloomington, MN 55420
612-854-6211

Resource Conservation Services
42 Main St.
Yarmouth, ME 04096
207-846-3737

Reuter, Inc.
410 11th Avenue, South
Hopkins, MN 55343-7878
612-935-6921

Riedel Waste Disposal Systems, Inc.
P.O. Box 5007
Portland, OR 97208
503-240-8692

Royer Industries, Inc.
P.O. Box 1232
Kingston, PA 18704
717-287-9624

SPM Group, Inc.
1601 W. 23rd St.
Suite 200
Lawrence, KS 66046
913-749-7222

Taulman, Inc.
415 E. Paces Ferry Rd., N.E.
Atlanta, GA 30305
404-262-3131

TRS Industries
10901 Lowell, Suite 125
Overland Park, KS 66210
913-661-9494

Voest-Alpine Composting System
c/o Chambers Development Co., Inc.
10700 Frankstown Rd.
Pittsburgh, PA 15235
412-242-6237

WPF Corporation
P.O. Box 381
Bellevue, OH 44811
419-483-7752

Waste Management
3003 Butterfield Rd.
Oak Brook, IL 60521
312-572-8800

Waste Processing Corp.
One Appletree Square
Suite 961
Bloomington, MN 55425
612-854-8666

COMPOSTING TURNERS

A-1 Environmental
16350 WCR 76
Eaton, CO 80615
800-255-4144

Brown Bear Corp.
P.O. Box 148
Lenox, IA 50851
515-333-4551

Eagle Crusher Co., Inc. (Cobey Composter)
4250 S.R. 309
Galion, OH 44833
419-468-2288

Resource Recovery Systems of Nebraska
Route 4
Sterling, CO 80751
303-522-0663

Scarab Manufacturing
Route 2, Box 40
White Deer, TX 79097
806-883-7621

Scat Engineering
P.O. Box 266
Delhi, IA 52223
319-922-2981

Wildcat Mfg. Co.
Box 23
Freeman, SD 57029
605-925-4512

CONVEYORS

American Pulverizer
5540 W. Park Avenue
St. Louis, MO 63110
314-781-6100

AR Products
P.O. Box 703
Indian Trail, NC 28079
704-821-6342

ATARA Inc.
1114 Goffle Road
Hawthorne, NJ 07506
201-423-9411

Athey Products Corp.
P.O. Box 669
Raleigh, NC 27602
919-556-5171

C-Tech Conveyor Corp.
P.O. Box 1068
Branford, CT 06405
203-481-2141

Carrier Equipment, Inc.
P.O. Box 37070
Louisville, KY 40233
502-969-3171

Dover Conveyor
P.O. Box 300
Midvale, OH 44653
614-922-9390

Esco Corporation
2141 N.W. 25th Ave.
Portland, OR 97210
503-228-2141

Hallco Mfg. Co.
P.O. Box 20519
Seattle, WA 98102
206-282-0653

Hustler Conveyor Co.
4985 Fyler Avenue
St. Louis, MO 63139
314-352-6000

Keith Manufacturing Co.
P.O. Box 1
Madras, OR 97741
503-475-3802

Lummus Development Corporation
P.O. Box 2526
Columbus, GA 31902
404-323-1081

Mayfran International
6650 Beta Drive
Mayfield, OH 44143
216-461-4100

Nott Company
P.O. Box 1422
Minneapolis, MN 55440
612-781-9561

Prab Conveyors, Inc.
5944 E. Kilgore Road
Kalamazoo, MI 49001
616-349-8761

Rapin Machinery, Inc.
200 Rapin Place
Buffalo, NY 14211
716-893-3303

Recovery Systems
Technology, Inc.
18012 Bothell Hwy., SE
Bothell, WA 98012
206-486-3547

Recycling Equipment Manufacturing
N. 6512 NAPA
Spokane, WA 99207
509-487-6966

Rexnord, Inc.
P.O. Box 2022
Milwaukee, WI 53201
414-643-3000

Selco Products, Inc.
P.O. Box 406
Baxley, GA 31513
912-367-4661

Serpentix Conveyor Corp.
9085 Marshall Ct.
Westminster, CO 80030
303-430-8427

Jervis B. Webb Co.
Webb Drive
Farmington Hills, MI
48018
313-553-1220

Webb Materials Handling Equipment
560 Ind. Drive, N.E.
Marietta, GA 30062

Wolf & Associates
4860 Mustang Circle
St. Paul, MN 55112
612-780-4550

Universal Engineering
800 1st Avenue, N.W.
Cedar Rapids, IA 52405
319-365-0441

DEWATERING SYSTEMS

AFL Industries, Inc.
3661 W. Blue Heron
Riviera Beach, FL 33404
305-844-5200

Alar Engineering Corp.
9651 W. 196th St.
Mokena, IL 60488
312-479-6100

Andy River, Inc.
Box 4420, Hatch Rd.
Lisbon, ME 04250
207-353-9311

Arus-Andritz
Arlington S.Ind. Pk.
1010 Commercial Blvd.
S. Arlington, TX 76017
817-465-5611

Ashbrook-Simon-Hartley
11600 E. Hardy
Houston, TX 77093
713-449-0322

Bio Gro Systems
180 Adm. Cochrane Dr.
Suite 305
Annapolis, MD 21401
301-224-0022

Bio-Nomic Resources
1101 Richmond Ave.
Pt. Pleasant Beach, NJ
08742
201-295-3551

Brown Bear Corp.
P.O. Box 148
Lenox, IA 50851
515-333-4551

The Carylon Group
2500 W. Arthington St.
Chicago, IL 60612-4108
800-621-4342

DeWatering Technologies
1501 Verti Dr.
Winslow, ME 04901
207-873-0975

Envirex
P.O. Box 1067
Waukesha, WI 53187
414-547-0141

Enviroquip, Inc.
P.O. Box 9069
Austin, TX 78766
512-836-1614

F.B. Leopold Co., Inc.
227 S. Division St.
Zelienople, PA 16063
412-452-6300

Hydropress, Inc.
59 Dwight St.
Hatfield, MA 01038
413-247-9656

Infilco Degremont, Inc.
P.O. Box 29599
Richmond, VA 23229
804-281-7600

J.D. Meagher & Co.
P.O. Box 752
Westborough, MA 01581
617-366-6606

Jones Environmental
1931 Industrial Dr.
Libertyville, IL 60048
312-367-5440

K-F Environmental Technologies, Inc.
17 Furler St.
Totowa, NJ 07512
201-256-6226

Komline-Sanderson Engineering Corp.
12 Holland Ave.
Peapack, NJ 07977
201-234-1000

National Dredging & Pumping Corp.
Box 127
Folcroft, PA 19032
215-237-0700

Parkson Corp.
P.O. Box 408399
Ft. Lauderdale, FL 33340
305-974-6610

Plesh Industries, Inc.
One River Rock Dr.
Buffalo, NY 14207
716-873-4916

Roediger Pittsburgh, Inc.
3812 Route 8
Allison Park, PA 15101
412-487-6010

Somat, Inc.
Pomeroy, PA 19367-9990
215-384-7000

D.R. Sperry & Co.
112 N. Grant St.
North Aurora, IL 60542

Stord Bartz Americas
309 Regional Rd., S.
Greensboro, SC 27409
919-668-7727

Tetra
P.O. Box 73087
Houston, TX 77273
800-327-7817

Tricil Environmental Response
P.O. Box 19529
Houston, TX 77224
713-467-3433

MARKETING

American Soil Products
2222 Third St.
Berkeley, CA 94710
415-540-8011

Bird Compost Management
4140 Skyron Drive
Doylestown, PA 18901
215-348-9788

Kellogg Supply Co.
350 W. Sepulveda Blvd.
Carson, CA 90745
213-830-2206

PRSM
882 S. Matlock St.
Unit E
West Chester, PA 19382
215-430-3960

Soil Products, Inc.
P.O. Box 145
Hermitage, TN 37076
615-889-4091

MATERIALS HANDLING

Ag-Bag Corp.
P.O. Box 418
Astoria, OR 97103

Aggregates Equipment
P.O. Box 39
Leola, PA 17540
717-656-2131

Bio Gro Systems
180 Adm. Cochrance Dr.
Suite 305
Annapolis, MD 21401
301-224-0152

Buhler, Inc.
P.O. Box 9497
Minneapolis, MN 55440
612-545-1401

Converto Mfg., Inc.
P.O. Box 287
Cambridge City, IN 47327
317-478-3205

Duraquip, Inc.
P.O. Box 948
Dept. BC
Tualatin, OR 97062
503-639-9826

East Mfg. Co.
P.O. 277
Randolph, OH 44265
216-325-9921

Eastern Conveyor Co.
P.O. Box 9584
Philadelphia, PA 19124
215-289-7585

Kolman/Athey
Box 806
Sioux Falls, SD 57101
605-336-2610

Laidig, Inc.
14535 Dragoon Trail
Mishawaka, IN 46544
219-256-0204

Layco Mfg., Inc.
RR #2, P.O. Box 100
Marshall, IL 62441
217-826-6352

Nott Co.
P.O. Box 1422
Minneapolis, MN 55440
612-781-9561

Phelphs Industries, Inc.
P.O. Box 1093
Little Rock, AR 72203
501-375-1141

Retec, Inc.
P.O. Box 724634
Atlanta, GA 30339
404-446-1378

Royer Industries, Inc.
P.O. Box 1232
Kingston, PA 18704
717-287-9624

Tink, Inc.
2361 Durham-Dayton Hwy.
Durham, CA 95938
916-895-0897

MIXING

Amadas Industries
1100 Holland Rd.
Suffolk, VA 23434
804-539-0231

Brown Bear Corp.
P.O. Box 148
Lenox, IA 50851
515-333-4551

Can-Am Mixers
P.O. Box 5318
Fullerton, CA 92635

Cemen Tech
1100 N. 14th St.
Indianola, IA 50125
515-961-7407

Davis Pugmill, Inc.
P.O. Box 60
Columbia, TN 38402-0060
615-388-0625

JWI, Inc.
2155 112th Ave.
Holland, MI 49423
616-772-9011

Knight Industrial Div.
P.O. Box 167
Brodhead, WI 53520
608-897-2131

Koch Engineering
P.O. Box 8127
Wichita, KS 67208
316-832-5110

Koppers Co.
Sprout Waldon Div.
Muncy, PA 17756
717-546-8211

F.B. Leopold Co.,Inc.
227 S. Division St.
Zelienople, PA 16063
412-452-6300

Littleford Bros.,Inc.
7451 Empire Drive
Florence, KY 41042
606-525-7600

McLanahan Corp.
200 Wall Street
Hollidaysburg, PA 16648
814-695-9807

Processall
10596 Springfield Pike
Cincinnati, OH 45215
513-771-2266

Scat Engineering
P.O. Box 266
Delhi, IA 52223
319-922-2981

Scott Equipment
605 4th Ave., N.W.
New Prague, MN 56071

Sludge Systems International
P.O. Box 265
1125 Starr Ave.
Eau Claire, WI 54702
715-835-3151

Zimmerman Industries
Box 10106
Ephrata, PA 17522
717-733-6166

ODOR CONTROL AND AERATION SYSTEMS

BioFiltration, Inc.
P.O. Box 15268
Gainesville, FL 32604
904-375-80001

Calvert Environmental
5985 Santa Fe St.
San Diego, CA 92109
619-272-0050

Chicago Blower Corp.
1675 Glen Ellyn Rd.
Glendale Hts., IL 60139
708-858-2600

Duall Division
700 S. McMillan St.
Owosso, MI 48867
517-725-8184

NuTech Environmental
5350 N. Washington St.
Denver, CO 80216
800-321-8824

PEPCON Systems, Inc.
PO Box 797
Henderson, NV 89015
702-565-8741

Purafil, Inc.
P.O. Box 287
Onconomowoc, WI 53066
414-567-0094

Quad Environmental
Systems
4284 Overland Trail
Kettering, OH 45429
513-293-8496

SCREENS

Amadas Industries
1100 Holland Road
Suffolk, VA 23434
804-539-0231

American Recycling Equip.
3141 Bordentown Ave.
Parlin, NJ 08859
908-525-1104

Central Mfg., Inc.
P.O. Box 1900
Peoria, IL 61656
309-387-6591

Enviro-Care Co.
5614 W. Grand Ave.
Chicago, IL 60639
312-745-7773

Falcon Equipment, Inc.
P.O. Box 339
Gardena, CA 90247
213-327-4880

Finlay Hydroscreens
248 US Rt. 9
Bayville, NJ 08721
201-269-8600

Fuel Harvesters Equipment
12759 Loma Rica Dr.
Grass Valley, CA 95945
916-272-7664

The Heil Company,
Engineers Sytems Div.
Arbor Terrace II
205 Bishops Way
Suite 201
Brookfield, WI 53005
414-789-5533

Krebs Engineers
1205 Chrysler Dr.
Menlo Park, CA 94025
415-325-0751

Lindemann Recycling Equipment
500 Fifth Ave.
New York, NY 10110
212-382-0630

Lindig Manufacturing
Box 106
St. Paul, MN 55113
612-633-3072

Ohio Central Steel Co.
7001 Americana Pkwy.
Reynoldsburg, OH 43068
800-837-3344

Parker Manufacturing
18012 Bothell Hwy., S.E.
Bothell, WA 98012
206-486-3547

Powerscreen of America
11300 Electron Drive
Louisville, KY 40299
502-267-2314

Rader Companies, Inc.
P.O. Box 20128
Portland, OR 97220
503-255-5330

Read Corporation
P.O. Box 1298
Middlebore, MA 02346
800-992-0145

Resource Recovery Systems, Inc.
Box 32965
Detroit, MI 48232
519-736-5481

Royer Industries, Inc.
P.O. Box 1232
Kingston, PA 18704
717-287-9624

SPM Group, Inc.
1601 West 23rd
Suite 200
Lawrence, KS 66046
913-749-7222

Sweco, Inc.
P.O. Box 4151
Los Angeles, CA 90051

Triple/S Dynamics, Inc.
1031 S. Haskell Ave.
Dallas, TX 75223
214-828-8600

West Salem Machinery
P.O. Box 5288
Salem, OR 97304
503-364-2213

Wheel-Air-Flow
P.O. Box 18190
Minneapolis, MN 55418
612-781-3461

Wildcat Mfg. Co.,Inc.
Box 23
Freeman, SD 57029
605-925-4512

SIZE REDUCTION

A-1 Environmental
16350 WCR 76
Eaton, CO 80615
501-471-4144

Allegheny Paper Shredders Corp.
Old Wm. Penn Hwy. E.
Delmont, PA 15626
412-468-4300

American Pulverizer Co.
5540 W. Park Ave.
St. Louis, MO 63110
314-781-6100

American Recycling Equip.
3141 Bordentown Ave.
Parlin, NJ 08859
908-525-1104

Bandit Industries
6750 Millbrook Rd.
Remus, MI 49340
517-561-2270

Blower Application Co.
W19125 Clinton Drive
Germantown, WI 53022
414-255-3446

Columbus McKinnon
Audubon & Sylvan
Amherst, NY 14228
716-689-5400

Disposable Waste Systems
2600 S. Garnsey
Santa Ana, CA 92707
714-751-8100

Dresser Industries/
Jeffrey Mfg. Div.
P.O. Box 387
Woodruff, SC 29388
803-476-7523

Eidal Intl., Inc.
P.O. Box 509
Wilsonville, OR 97070
503-682-2992

Finn Corporation
9281 LeSaint Dr.
Fairfield, OH 45014
800-543-7166

Farmhand, Inc.
6421 Hazeltine Blvd.
Excelsior, MN 55331
612-474-1941

Fuel Harvesters Equipment
12759 Loma Rica Dr.
Grass Valley, CA 95945
916-272-7664

Gruendler Crusher
212 S. Oak
Durand, MI 48429
517-288-6662

Hammermills, Inc.
800 First Ave., N.W.
Cedar Rapids, IA 52405
319-365-0441

Haybuster Mfg., Inc.
P.O. Box 1940
Jamestown, ND 58402
701-252-4601

Hi-Torque Shredder Co.
230 Sherman Ave.
Berkeley Hts., NJ 07922
201-464-2002

Hosokawa Micron Intl.
10 Chartham Road
Summit, NJ 07901
908-273-6360

Industrial Paper
Shredders, Inc.
P.O. Box 180
Salem, OH 44460
216-332-0024

Iggesund Recycling
P.O. Box 380
Nisswa, MN 56468
218-963-4343

Innovator Mfg., Inc.
120 Weston St.
London, Ontario
Canada N6C 1R4
800-465-4747

Jacobson, Inc.
2445 Nevada Ave.,N.
Minneapolis, MN 55427
612-544-8781

Jones Manufacturing Co.
Route 1, Box 80
Beemer, NE 68716
402-528-3861

La Bounty Manufacturing
P.O. Box B
Two Harbors, MN 55616
218-834-2123

Lindemann Recycling Equipment
500 Fifth Avenue
Suite 1234
New York, NY 10110
212-382-0630

Lindig Manufacturing
Box 106
1877 W. Country Rd.
St. Paul, MN 55113
612-633-3072

Mac/Saturn Corp.
201 E. Shady Grove Rd.
Grand Prairie, TX 75050
214-790-7800

Mitts & Merrill
571 W. End Ave.
Carthage, NY 13619
315-493-2380

Montgomery Industries
P.O. Box 3687
Jacksonville, FL 32206
904-355-5671

Morrison-Knudsen Co.
P.O. Box 7808
Boise, ID 83729
800-635-5000

Newell Mfg. Co.
P.O. Box 9367
San Antonio, TX 78204
512-227-9090

Norcia
RD# 4, Box 451
N. Brunswick, NJ 08902
201-297-1101

Old Dominion Brush (ODB)
5118 Glen Alden Dr.
Richmond, VA 23231
804-226-4433

O & E Shredding Systems
P.O. Box 69
Green Bay, WI 54305
414-437-6587

Olathe Mfg., Inc.
100 Industrial Pkwy.
Ind. Airport,KS 66031
913-782-4396

Parker Manufacturing
18012 Bothell Hwy., S.E.
Bothell, WA 98012
206-486-3547

Promark Products, Inc.
330 9th Ave.
Industry, CA 91746
818-961-9783

Proveda
100 Jerry Drive
Jackson Ctr., OH 45334
513-596-6713

Recycling Systems
P.O. Box 364
Winn, MI 48896
517-866-2800

Seppi Company
N56 W35700 Lisbon Rd.
Oconomowoc, WI 53066
414-567-0437

Shred-Tech Limited
P.O. Box 1508
Cambridge, Ontario
Canada N1R 7G8
519-621-3560

Shredding Systems, Inc.
P.O. Box 869
Wilsonville, OR 97070
503-682-3633

Sterling Grinder Co., Inc.
Box 1257
Sterling, CO 80751
303-522-1200

Stumpmaster, Inc.
P.O. Box 103
Rising Fawn, GA 30738
404-462-2445

Sundance
P.O. Box 2437
Greeley, CO 80632
303-353-8700

Triple/S Dyamics, Inc.
1031 S. Haskell Ave.
Dallas, TX 75223
214-828-8600

United Farm Tools, Inc.
Miller Div.
P.O. Box 336
Turlock, CA 95381
209-632-3846

Universal Engineering
Div. of Pettibone Corp
800 First Ave., NW
Cedar Rapids, IA 52405
319-365-0441

Valby Woodchippers
Northeast Implement Corp.
Box 402
Spencer, NY 14883
607-589-6160

Walluski Western Ltd.
P.O Box 642
Astoria, OR 97103
503-325-5187

Waste Technologies, Inc.
505 W. 6th Street
Papillion, NE 68128
402-592-5520

West Salem Machinery
P.O. Box 5288
Salem, OR 97304
503-364-2213

Williams Patent Crusher & Pulverizer Co.
2701 N. Broadway
St. Louis, MO 63102
313-621-3348

R.M. Wilson Co.
P.O. Box 6274
Wheeling, WV 26003
304-232-5860

Wor-Tex Corp.
P.O. Box 636
Hillsboro,TX 76645
817-582-5354

SPREADERS & APPLICATORS

Ag-Chem Equipment Co.
5720 Smetana Dr.
Suite 100
Minnetonka, MN 55343
612-933-9006

Amadas, Inc.
1100 Holland Road
Suffolk, VA 23434
804-539-0231

Field Gymmy
Box 121
Glandorf, OH 45848
419-538-6511

Gehl Company
143 Water St.
West Bend, WI 53095
414-334-9461

Henderson Mfg.
P.O. Box 40
Manchester, IA 52057
319-927-2828

Highway Equip. Co.
616 Dave, N.W.
Cedar Rapids, IA 52405
319-363-8281

Knight Mfg.
1501 W. 7th Ave.
Brodhead, WI 53520
608-897-2131

L.W.T., Inc.
Box 250
422 Mill Street
Somerset, WI 54025
715-247-5464

Mill Creek Mfg. Co.
112 S. Railroad Ave.
New Holland, PA 17557
717-355-2446

New Holland
500 Diller Ave.
New Holland, PA 17557
717-354-1121

Stallion-Beiler Equipment Company, Inc.
R.D. 1
Massey, MD 21650
301-928-3009

THERMOMETERS, MONITORING

Meriden Cooper Corp.
Box 692
Meriden, CT 06450
203-237-8448

Omega Engineering, Inc.
1 Omega Dr.
Stamford, CT 06907

Reotemp Instrument Corporation
11568 Sorrento Valley Rd. #10
San Diego, CA 92121
619-481-7737

Tech-Line Instruments
P.O. Box 1236
Fond du Lac, WI 54935
800-328-7518

Walden Instrument Supply Co.
910 Main St.
Wakefield, MA 01880
617-245-2944

Appendix C

Compost Technologies

Compost technologies can be broadly divided into four groups: turned windrow, static pile, in-vessel, and hybrid (which is a combination of technologies). Examples of each are given below.

Turned windrow	Agripost, Inc.
	Ecological technologies (Ecotech), Inc.
	Environmental Recovery Systems, Inc.
	Compost Management Associates Ltd.
Static Pile	Buhler-Miag, Inc.
	Daneco
	WPF Corporation
In-vessel	Airite Environmental Industries Inc.
	American Recovery Corporation
	Ashbrook-Simon-Hartley
	Bedminster Bioconversion Corp.: The Eweson Process
	Compost Systems Company (Paygro and Dynatherm)
	Double T Equipment Manufacturing Ltd.
	Ebara Environmental Corp.
	Fairfield Service Company
	OTVD Group Energies
	PURAC Engineering, Inc.
	Recomp
	Royer Industries
	Taulman Composting Systems
Hybrid	California Co-Composting Systems
	International Process Systems
	Harbert/Triga International, Inc.
	Waste Processing Corporation (Dano)

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